Electronic Engineering

NOVEMBER 1958

The outstanding RACAL RA.17 Receiver, nearly two thousand of which have been sold to civilian and military authorities throughout the world.

EE 3001 *for further details*

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The range of Ediswan Industrial valves is both extensive and comprehensive. The following is a selection from the all-glass valves on miniature bases used in industry and communications. We shall be pleased to send you full particulars of these valves or any others in which you may be interested. **EDISWAN** INDUSTRIAL VALVES

TYPE	CV.	OTHER EQUIVALENTS	BASE	HEATER	DESCRIPTION	TYPICAL USE	IMPORTANT PARAMETERS	
6F21	CV.131	9D6, EF92	B7G	6·3 volts	Variable mu H.F. Pentode	H.F. or L.F. Amplification	V_a (max) P_a (max) P_{g2} (max) g_m	300 volts 3 watts 0·7 watts 2·5 mA/V
6F33	CV.329 CV.2209	—	B7G	6·3 volts	H.F. Pentode with short suppressor grid base	Gating or variable reactance	V_a (max) P_a (max) Diode tied to g_3	250 volts 2·5 watts
6H1	CV.132	—	B7G	6·3 volts	Hexode	Gating or frequency changing	P_a (max) P_{g2} (max) g_m	1 watt 0·7 watts 2·1 mA/V
6L13	CV.429	12AX7, ECC83	B9G	6·3 volts	Double Triode	Amplification	V_a (max) P_a (max) μ	300 volts 2x1 watts 100
6P17	CV.136	6AM5, EL91	B7G	6·3 volts	Output Pentode	—	V_a (max) P_a (max) P_{g2} (max) Typical output	300 volts 4·75 watts 0·8 watts 1·4 watts
20A3	CV.797	2D21, EN91	B7G	6·3 volts	Xenon filled tetrode	Relay	P.I.V. (max) I_a peak (max) I_a mean (max) Control ratio (g_1) Control ratio (g_2)	1300 volts 50 mA 100 mA 250 1000
19G6	CV.371	—	B7G	4 volts	Half wave rectifier	High voltage power supply	P.I.V. (max) I_a peak (max) I_a mean (max)	6 kV 180 mA 30 mA

SIEMENS EDISON SWAN LIMITED *AN A.E.I. COMPANY.* 155 CHARING CROSS ROAD, LONDON W.C.2. AND AT BRANCHES

CRC 16/7

CLASSIFIED ADVERTISEMENTS

The charge for these advertisements is 6d. per word. Minimum charge 12s. Box number 2s. extra, except in the case of advertisements for "Situations Wanted", when it is free. Specially spaced advertisements per inch single column 42s. 6d. A remittance must accompany the advertisement. Replies to Box numbers should be addressed to: "Electronic Engineering", 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

ASSISTANTS (SCIENTIFIC). Pensionable posts for men and women. Age at least 17½ and under 26 (unless specially experienced) on 1.1.58. Extension for Forces or Overseas Civil Service. Appropriate educational or technical qualifications and at least two years relevant experience in one of the groups: (i) Engineering and physical sciences. (ii) Chemistry, bio-chemistry and metallurgy. (iii) Biological Sciences. (iv) General (including pathology, geology, meteorology, and highly skilled work in laboratory crafts such as glass-blowing). Starting pay from £340 up to £530. Men's maximum (London) £690. Opportunities for promotion and for further education. 5-day week, generally. Write Civil Service Commission, 30, Old Burlington Street, London, W.1., for application form quoting No. S 59/58. W 3130

BATTERSEA COLLEGE OF TECHNOLOGY, London, S.W.11. Applications are invited from graduates of a British University for two Lectureships in Physics. Preference will be given to specialists in Experimental Microwave Physics or Theoretical Metal Physics. Experience in teaching and/or research essential. Salary: Men, £1,200 by £30 to £1,350, plus London allowance of £36-£48, women, slightly lower rising to men's scale by 1961. Full particulars from the Clerk of the Governing Body, to whom applications should be sent as soon as possible. W 3169

CENTRAL ELECTRICITY GENERATING BOARD. Instrument engineer required in the Electronics and Instrument Section of the Research Laboratories, Leatherhead, Surrey. The Section provides an instrument service for all departments of the Laboratories, and duties include the maintenance, calibration and repair of a wide variety of physical, chemical and electrical instruments. Candidates should have a Higher National Certificate or equivalent qualification. Experience in electronic or nucleonic equipment will be an advantage. Salary on a scale within the range £550-£1,265 p.a., according to duties and responsibilities. Applications stating age, qualifications, experience, present position and salary should be forwarded to I. G. Ellis, Personnel Officer, 24-30, Holborn, London, E.C.1, by 10th November. Please mark envelopes "Confidential" ref. EE/301. W 3157

LIVERPOOL RADIUM INSTITUTE MANAGEMENT COMMITTEE, 1, Myrtle Street, Liverpool, 7. Applications are invited for the post of Electronics Technician (Senior Grade) in the Physics Department. Duties are mainly concerned with the maintenance of electronic measuring instruments for the Radio-Isotope Department. Candidates should be capable of maintaining the existing specialised equipment and of taking part in the development and installation of new apparatus. A sound knowledge of electronics is required, preferably with experience of pulse techniques. Whitley Council conditions of service and salary scale, viz., £625 to £810 per annum. Applications, giving full details of previous experience together with the names and addresses of two referees, to be sent to the undersigned not later than 10th November, 1958. D. Bryson. Secretary to the Committee. W 3148

MINISTRY OF SUPPLY require Technicians at Farnborough, Hants, Chessington, Surrey, or Malvern, Worcs., to prepare technical publications on the theoretical and practical aspects (general principles, operation maintenance and repair) of airborne and ground equipment for radio (including radar) control search and navigation. Qualifications: British of British parents. Should have served recognised engineering apprenticeship or have had equivalent training in electronic engineering. Must have sound theoretical knowledge of radio and good practical experience in this field in a position of technical responsibility. Some experience in writing or editing technical publications or of instructing in technical subjects, would be an advantage. Possession of O.N.C. appropriate City and Guilds Final Certificate or equivalent qualification is desirable. Rate of pay: Chessington—£870 (age 30) to £1,030 p.a. Farnborough or Malvern—£820 (age 30) to £974 p.a. Application forms from M.O.L.N.S., Ref. PE.1945, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. W 1370

MECHANICAL AND ELECTRICAL ENGINEERS. Pensionable posts for men and women normally under 35 on 1.9.58. Applicants must normally have Degree in Engineering or Physics (or Dip. Tech. for some posts) or have passed examinations necessary for A.M.I.Mech.E., A.M.I.E.E., A.F.R.Ae.Soc., etc. Exceptionally, evidence of high professional attainment acceptable in lieu. Practical training and experience required, but graduates without practical experience acceptable for some posts. Men's starting salary from £755 (lower if under 25) to £1,085. Maximum (London), £1,250. Promotion prospects.' Write Civil Service Commission, 30 Old Burlington Street, London, W.1, for application form, quoting S851/58. Closing date, 18 November, 1958. Earlier applicants may be interviewed before that date. W 3165

MINISTRY OF SUPPLY require Electrical, Electro-mechanical and Electronic Engineers for research and development, production and inspection branches and Ordnance Factories in London and Provinces. Qualifications: British of British parents. Recognised engineering apprenticeship or equivalent training. Corporate membership of Institution of Civil, Mechanical or Electrical Engineers or exempting qualifications. Sound knowledge of theory and practice of electronic or light electro-mechanical engineering. Salary: £805-£1,720 p.a. in London, according to age and experience. Slightly lower in Provinces. Appointments initially unestablished but good prospects of appointment to permanent staff. Forms from M. L. & N. S., Technical and Scientific Register (K), 26, King Street, London, S.W.1., quoting D.369/8A. Closing date 14th November, 1958. W 3144

MINISTRY OF SUPPLY Research and Development Establishments, mainly in southern half of England, require (a) Senior Scientific Officers (min. age 26) and (b) Scientific Officers for work in physics, electronics, electrical or mechanical engineering, applied mathematics, aerodynamics, chemistry or metallurgy. 1st or 2nd class hons. Degree or equivalent required and for S.S.O. at least 3 years post graduate experience. Starting salary in range (a) £1,130–£1,330, (b) £595–£1,050 (male, in provinces). Rates for women reaching equality in 1961. Superannuation under F.S.S.U. Opportunity for those under 32 to compete for established posts. Candidates should indicate fields of work in which interested. At National Gas Turbine Establishment, Pyestock, Hants, houses available for letting to married staff, and opportunities for new graduates to have workshop training. Forms from M.L.N.S. Technical and Scientific Register, 26, King Street, London, S.W.1 (quote A.300/8A).K W 3155

MINISTRY OF TRANSPORT AND CIVIL AVIATION requires Electrical Engineers (Assistant Signals Officers) for aviation telecommunications and electronic navigational aids. Min. age 23. First- or Second-Class Degree in Physics or Engineering, or A.M.I.E.E. or A.F.R.Ae.S. (Candidates with Parts I, II and III of A.M.I.E.E. or Parts I and II of A.F.R.Ae.S. or equivalent, or of very high professional attainment without these qualifications considered.) Salary, £665 (age 23) to £1,085 (age 34). Max. £1,250. Slightly lower outside London and for women. 5-day week. Further details and forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D129/8A. W 3167

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, London. Applications are invited, especially from those in industry, for the following appointments:- (a) Senior Lecturer in Electrical Power; (b) Assistant Lecturer in Electrical Engineering. The work of the department is concerned with degree and Sandwich (Dip. Tech.) and postgraduate courses in Electrical Engineering. The posts provide facilities for research, development and experience in industrial liaison. Applicants should possess a degree in Electrical Engineering. Salaries Scales: Senior Lecturer: £1,350 x £50—£1,550 per annum. Assistant Lecturer: £800 x £25—£1,175 per annum, plus, in each case, London allowance of £36 increasing to £48 at age 37. Particulars and form of application from the Secretary, Northampton College of Advanced Technology, St. John Street, E.C.1. W 3154

NORWOOD TECHNICAL COLLEGE, Telecommunications and Electronics Department. Four assistant Lecturers Grade B each for work in connection with one or more of the following courses to commence soon as possible:— a. Full-time, Sandwich and Part-time courses to level of the Full Technological Certificate in Telecommunications of the City and Guilds and for Graduate Membership of the British Institute of Radio Engineers. b. Full-time courses in Radio Operating for P.M.G. 1st and 2nd Class Certificates. c. Full-time and Part-time courses in Radar. d. Part-time courses in Radio and Television Servicing and Television Technology, etc. Candidates for work with courses A above should possess high professional qualifications in telecommunications or electronics; teaching and/or research experience an advantage. Those interested mainly in courses B above should have good qualifications and experience as a radio officer; additional qualifications under the headings A, C or D would be an advantage. Salary —Burnham Scale Grade B within the range £650-£1,225 according to qualifications and experience. Plus London allowance of £36 or £48. All posts temporary in the first instance. Application forms from principal (S.A.E.) to be returned by 5 November 1958. (2019). W 3173

PATENT OFFICE: EXAMINERS (men and women) for scientific, technical and legal work on Patent applications. Age between 21 and 35; extension for regular Forces service and Overseas Civil Service. Qualifications: normally first or second class honours degree in physics, chemistry, engineering, metallurgy or mathematics, or equivalent attainment, or professional qualification, e.g., A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. London salary (men) £635-£1,410; provision for starting pay above minimum. Good promotion prospects. Apply Civil Service Commission, 30, Old Burlington Street, London, W.1. for application form, quoting S128/58 and stating date of birth. W 3129

RESEARCH. The National Coal Board's Mining Research Establishment, Worton Hall, Isleworth, Middx. undertakes research to improve the efficiency and effectiveness of mining methods. Technical problems studied include the breakage and mechanical properties of coal and rock, the behaviour of strata under load, and environmental conditions and hazards. In association with these studies important work on instrumentation is carried out both for underground use and for laboratories. Work is carried out mainly in the well-equipped laboratories at Isleworth and occasionally on Field trials in pits. Applications are invited for the following superannuable appointments. Electronic Engineers or Physicists to assist in design and development of mechanical and electronic instruments for use in laboratories and mines. One post requires an Honours degree in Light Current Electrical Engineering or Physics, others require H.N.C. in Electrical Engineering or applied Physics. Applicants should have had experience in research or development of electronic or electro-mechanical instruments. The senior post will be in the scale £1,059-£1,468, others in the scale £671-£907 or £976-£1,138. (Ref. X.-1266.I.). Write to the Personnel Officer at the above address, quoting relevant number for application form which should be completed and returned by 17th November, 1958. W 3138

SENIOR SCIENTIFIC OFFICERS (*a*); Scientific Officers (*b*). Pensionable posts for men and women in major scientific fields, including meteorology and geophysics (frequent overseas surveys). A few vacancies for biologists including specialised posts in taxonomy of invertebrate animals, fungus systematics, plant pathology and one post for a taxonomic botanist (Pteridophyta). Also a few posts in Home Office for Chemists and Physicists in Forensic Science field and one post for Mathematician/Physicist to work on Civil Defence problems. Qualifications: Normally First or Second Class Honours Degree in Science, Mathematics or Engineering, or equivalent attainment; additionally, for (*a*), at least three years' relevant (e.g., post-graduate) experience. Normal age limits: (*a*) between 26 and 31, (*b*) between 21 and 28, with extensions for Regular Forces service and Overseas civil service. London salaries (men): (*a*) £1,190 to £1,410, (*b*) £635 to £1,110. Five-day week generally. Write Civil Service Commission, 30 Old Burlington Street, London, W.1, for application form, quoting (*a*) S.53/58, (*b*) S.52/58. W 3159

OFFICIAL APPOINTMENTS (Cont'd.)

HARROW TECHNICAL COLLEGE, Station Road, Harrow, Middlesex. Middlesex County Council Education Committee. Required as soon as possible: (a) Senior Lecturer in Electrical Engineering (Light Current). Applicants must be graduates and have good industrial and teaching experience. This post is for the development and Higher National Certificate and Endorsement courses in Electronics. Burnham (Technical) Salary Scale. Apply immediately (S.A.E.) to The Principal, C. E. Gurr, M.Sc., Ph.D., Secretary to the Education Committee. W 3133

TECHNICIAN, Nuclear Engineering Laboratory, for research work in electronics and nucleonics. Queen Mary College (University of London), Mile End Road, E.1. Salary placing according to ability on scale £420—£20—£570, plus London Weighting £20 or £30 according to age. Five-day week. Four weeks' annual holiday. Pension Scheme. Letters to Registrar (NT), stating age, full details experience and present work. W 3151

UNIVERSITY COLLEGE, LONDON (Gower Street, W.C.1.) requires Electronics Senior Technician for development and servicing work. Salary up to £720 p.a. Application forms from Secretary, quoting Electronics/1. W 3164

UNIVERSITY OF BRISTOL Electrical Engineering Department. Vacancies, both senior and junior, are likely to occur within the next year or two on the academic staff of this department in either the Power or Radio sections of the department. Salaries and conditions will be according to the usual University scales and standards, with initial salary according to qualifications and experience. The department has recently been transferred to excellent new premises, and substantially re-equipped, and facilities for research are good. Persons who contemplate seeking a post on the staff of a University department of electrical engineering either immediately or within the next year or two are invited to submit details of their careers and records to date. Submission of particulars will entail no obligation, either to the applicant or to the University. H. C. Butterfield, Secretary and Registrar, The University, Bristol. W 3118

VACANCIES EXIST AT the Atomic Weapons Research Establishment, Woolwich Common, S.E.18. Post 1 (Ref. A1856/42) Engineer (Main Grade). To develop and advise on the use of plastics in the production of electronic and high voltage electromechanical equipment; to investigate and develop new production techniques and to design injection mould tools for production. A recognized apprenticeship and A.M.I.E.E. or Mech.E. required. Familiarity with modern workshop practice is necessary and some knowledge and experience of electronic production. A knowledge of manufacturing methods using Epoxy resins is desirable. Salary, £1,400-£1,840. Post 2 (Ref. A1855/42) Technician. To assist with the development of processing and impregnating of a wide variety of electro-mechanical equipment. To investigate new methods of impregnation and to contribute to the design of prototype equipment and to supervise assembly. A full apprenticeship or training in an engineering or allied trade, followed by some years of experience in a trade appropriate to the needs of the work. A thorough knowledge of modern electronic components is required. An O.N.C. in electrical or mechanical engineering or an equivalent standard of technical education is desirable. H.N.C. would also be an advantage. Salary, £944 12s.-£1,134. There is a Contributory Superannuation Scheme in operation for both of these posts. Postcards for application forms to the Senior Recruitment Officer at A.W.R.E., Aldermaston, Berks. Please quote appropriate reference number. W 3150

WAR DEPARTMENT requires Lecturer at R.E.M.E. Training Centre, Arborfield, Berks, to teach Electronics or Light Current Subjects from S2 Standard to H.N.C. Standard. University Degree or equivalent required. Teaching experience essential. Further training available to successful candidate to complete specialization in Pulse Techniques, Guided Missiles Techniques or Advanced Electronics. Salary, £650-£1,025, with usual allowances according to Burnham Technical Scale for Assistant "B", plus special £115 non-pensionable allowance. Teacher's Superannuation. Full details and forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1. (Quote D383/8A.) Closing date, 15 December, 1958. W 3166

THE PLANT ENGINEERING & ENERGY DIVISION of the British Iron & Steel Research Association is engaged on research into analogue and digital feedback automatic control systems, information handling and methods of analogue to digital conversion, for the benefits of the British Steel industry. A junior electrical engineer is required to work on the theory and practice of digital systems and information handling. The possibilities of technological development on the digital side are countless and the field is almost unexplored. A University degree (preferably with honours) is essential. B.I.S.R.A. has two large and four small establishments and the present vacancy is in the London Engineering Laboratories. The Association has an enlightened outlook on research and development work, is well equipped and the right man can expect early recognition of successful work. Starting salary in the range of £780 to £990 according to age qualifications and experience. Post is superannuated under the F.S.S.U. Written applications only quoting "E.11." to the Personnel Officer, B.I.S.R.A., 11, Park Lane, London W.1. W 3149

SITUATIONS VACANT

AIRCRAFT MANUFACTURERS in the Midlands require test engineers for electro-hydraulic control systems. Low-frequency electrical experience is required and hydraulic experience would be an advantage but not essential. Apply giving details education and experience to: Box No. W 1085.

A KEEN, INTELLIGENT ENGINEER required for Siemens & Halske Rectifiers and other components. Previous experience Radio/Electronics Industries essential. Interesting position with scope for advancement. Apply in writing, stating age, experience and salary required, to Secretary, R. H. Cole (Overseas) Ltd., 2 Caxton Street, London, S.W.1. W 1099

BRITISH MANUFACTURE AND RESEARCH CO., LTD. have vacancies for men with initiative, in each of the following grades: (1) Electrical Development Engineers: Graduates, age 25 to 35, to undertake the development of advanced electromechanical control equipment in the laboratory and in the field and to carry out technical liaison with associated companies in Britain and abroad. Knowledge of basic servomechanism theory desirable. (2) Junior Circuit Designers/Draughtsmen: H.N.C. or equivalent, to carry out control circuit design in drawing office and laboratory under the guidance of a senior engineer. Pension/superannuation scheme, canteen, sports and social facilities available. Written applications with full particulars, including age, qualifications, experience, and salary required, to Chief Electrical Engineer, B.M.A.R. Co. Ltd., Grantham, Lincs, quoting ref. AWK/MF/ELE. W 339

CHIEF ENGINEER for small, but expanding Electronics Company in West London area engaged in the production of electronic and kindred assemblies to Services and high Commercial Standards. Age 30/35. Experience of technical administration essential. Degree or A.M.I.E.E. desirable. The successful applicant will be required to take full responsibility for the engineering and development of electronic apparatus from the laboratory stage onward to completion. A high salary will be paid and there are good prospects of advancement with the growth of the Company. Write Box No. W 3156.

DECCA RADAR LIMITED. Electro-Mechanical Engineer. The Electro Mechanical Section of the Development Division have a vacancy for an Electrical Engineer, age approximately 23 to 35. The section is engaged on the design of a wide range of servos and light mechanisms associated chiefly with presentation of radar data. This is a small design group where each member has a large measure of responsibility for his own designs. Previous experience of this type of work is essential, as also is an H.N.C. or Degree in Electrical Engineering. Applications should be made in writing to the Chief Development Engineer (EM), Decca Radar Ltd., 9 Davis Road, Chessington, Surrey. W 3163

ANALOGUE COMPUTER ENGINEER. A vacancy exists in the Electronics Department at A. V. Roe & Co., Limited, Chadderton for an experienced Electronics Engineer. Applicants should preferably be University Graduates with at least five years post-graduate experience in development work associated with Analogue Computers. Modern Equipment, Good Working Conditions, Excellent Opportunities for Advancement. Transport, Canteen and Social Facilities provided and a Superannuation Scheme. Applications, giving full particulars should be addressed to: The Personnel Manager, A. V. Roe & Co., Limited, Greengate, Middleton, Manchester, quoting Reference No. ACDG/JA/R.-216/E. W 3134

AN ELECTRONIC ENGINEER required for a laboratory situated in South Northants. The work involves the design, construction and maintenance of test gear which is being used by research personnel. A knowledge of components would be useful, and the applicant should possess a University Degree or equivalent qualification. Box No. W 3152.

DESIGN ENGINEER FOR CAPE TOWN, South Africa. This top ranking position is shortly becoming vacant. A Design Engineer of the highest calibre in the light current field with the accent on industrial electronic equipment and transformer design is required. An attractive salary being offered to an experienced applicant. The position calls for high technical qualifications, progressive ideas and, what is really essential, a practical outlook. These qualifications are necessary in order to produce equipment for the market that is of high quality and yet competitive. A written application is invited in the first instance, giving full details of educational and academic qualifications, together with achievements in the practical field, to Box No. W 3171.

DEVELOPMENT ENGINEERS required for work on electronic and electrical instruments:— (a) Senior electronic engineer to control work on electronic instruments. Preferably of degree standard and experienced in this work. (b) Electronics engineers. To help in development work in connection with instruments. H.N.C. standard or equivalent. (c) Instrument engineers. To help on development work on electrical instruments generally. H.N.C. standard or equivalent. Apply stating age, experience and salary required to Research Manager, Evershed and Vignoles Ltd., Research Laboratories, North Circular Road, (Corner of Iveagh Avenue), N.W.10. W 1077

DIGITAL COMPUTERS. Senior Electronics Engineers are required by a prominent electrical manufacturing company to lead design teams engaged in development of the latest in transistorised computers. For the right man these positions command a salary in the region of £1,500 per annum, and the expense of removals will be subsidised by the Company. For a post that offers a secure future in excellent working conditions, applications giving full details of age, qualifications and experience should be sent to Box No. W 3140.

ELECTRONIC DESIGNER. Engineering company, south Hampshire, equipped with a very fine range of precision machine tools and with substantial cash resources wishes to enter the electro-mechanical field, and therefore requires a first-class electronic designer with contacts with the Admiralty, Ministries and industry generally. The man required must have confidence in his own ability to build up from scratch a division for which he would be responsible. The remuneration would be commensurate with the position envisaged. Assistance with housing could be arranged. Box No. W 1089.

ELECTRONIC ENGINEER required by large manufacturing company in North East London area, whose policy it is to apply the latest electronic techniques whereever applicable to their existing and future manufacturing plants. The position is pensionable and permanent. Welfare and canteen facilities available. Full details of age and experience, together with salary required to: Personnel Manager, London Rubber Company Limited, North Circular Road, Chingford, London, E.4. W 1087

CLASSIFIED ADVERTISEMENTS
continued on page 4

EE 3003 *for further details*

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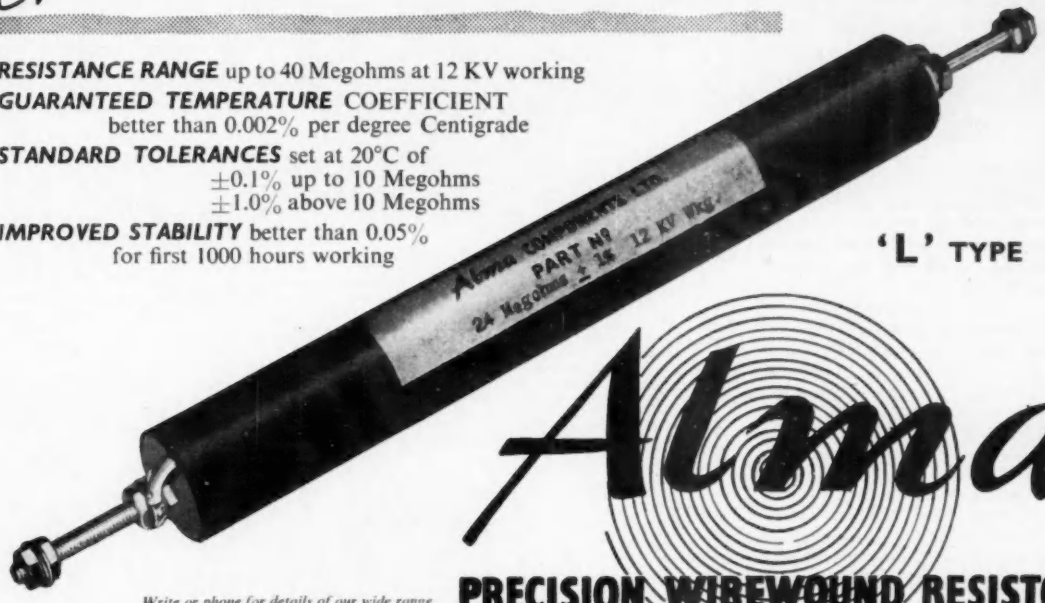

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SITUATIONS VACANT (Cont'd.)

DRAUGHTSMAN REQUIRED for layout and mechanical design of Electronic Equipment. Excellent prospects for advancement in expanding company. Rivlin Instruments Ltd., Doman Road, Camberley, Surrey. Camberley 2507/2508. W 1090

ELECTRICAL ENGINEER, qualified, required for small company in London, W.1., subsidiary of famous group, for development of X-ray apparatus and allied projects. Practical outlook and some industrial experience essential; X-ray experience desirable. Preferred age 25-35; good prospects and pension scheme. Box No. W 1095.

ELECTRONIC ENGINEERS. Electronic Engineers are required for work on a number of projects in the Department of Research and Technical Development of Stewarts and Lloyds, Limited, Corby, Northants:- 1. A Senior Engineer is required for the engineering supervision of a large digital computer. Specialised theoretical and practical training in computers will be provided. 2. Development Engineers are required for work on non-destructive testing and for advanced work in the process control field. A minimum qualification of Higher National Certificate, full City and Guilds Telecommunications Certificate, or the equivalent, is required and previous experience would be an asset. Housing conditions in Corby are favourable. The Company operates a Staff Pension and Group Life Insurance Scheme. Applications should be sent to the Manager/Personnel, Stewarts and Lloyds, Limited, Corby, Northants. W 3153

ELECTRONICS ENGINEER required for the development of telephone and allied equipment. Applicants should not only be experienced in the telephone field, but also have a good working knowledge and previous practical experience in electronic techniques. Application, giving full details of past experience and positions held, should be addressed to Personnel Manager, Pye Telecommunications Ltd., Newmarket Road, Cambridge. W 3112

ELECTRONIC PRODUCTION PLANNING ENGINEER. A well-established Engineering Company situated in West Middlesex have an opening for a well-qualified Electronic Production Planning Engineer with a sound theoretical knowledge of Electronics, backed by some years of good practical experience in the radio and television industry, to establish processes and methods in the manufacture of new products. Applicants should provide full information regarding technical education, training and industrial experience, by letter, to Box No. W 3168.

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

DRAUGHTSMEN. Required for Electronics Section. Previous experience in this field desirable, but not essential. Good salaries and prospects. Written applications with full details age, experience, etc., to Personnel Manager, Marshall Airport Works, Cambridge, quoting D/E.1. W 1094

GRADUATES interested in Electro-Chemistry are required by an electrolytic condenser manufacturing company in South-West England. Some industrial experience would be an advantage but is not essential, since it is proposed to train successful candidates. The training will consist of a probationary period at the production plant followed by six months to one year on relevant study and experiment at the Company's Materials Research and Development Laboratories in a country district in the South Midlands. Following this preliminary training they will be given technical appointments associated with process control and product development, but will maintain liaison with the Research Group. Every opportunity will be given for the development of new ideas and the advancement of status. Box W 3092.

INSTRUMENT ENGINEER, (30), with Degree or similar qualifications, for work in field of rocket motor design and development with broad knowledge of electrical, mechanical and electronic methods of measurement, and experience of process instrumentation. Should have recent design experience of any one of the following:—(a) Electrical, pressure, thrust or acceleration transducers; (b) Transistor circuits; (c) Digital computer techniques; (d) D.C. amplifiers; or (e) Frequency modulation techniques. Work is at Research Station, Summerfield, near Kidderminster, Worcestershire. Application form from Staff Manager, Imperial Chemical Industries Limited, P.O. Box No. 216, Kynoch Works, Witton, Birmingham 6, quoting GW/339/EE. W 3145

JUNIOR ELECTRONIC ENGINEER required for development work on a wide range of equipment. First class opportunity to gain experience in small but busy laboratory. Rivlin Instruments Ltd., Doman Road, Camberley, Surrey. Camberley 2507/2508. W 1091

MUIRHEAD & CO., LIMITED, Beckenham, Kent, require Electronic Test Engineer with H.N.C. or equivalent for testing of Precision Electronic Instruments and Facsimile equipment. This is a staff appointment with ideal working conditions. Salary commensurate with qualifications and experience. A Pension Scheme is in operation and the Company has its own Sports Ground. Written applications, giving full particulars, should be addressed to the Personnel Manager. W 3160

MULLARD RESEARCH LABORATORIES have vacancies for Honours Physicists and experienced Electromechanical Engineers to carry out research and advanced development in the Electronics Division. The work is extremely varied and ranges from research into new circuits and devices to the design of complete systems. It includes specific projects and also technique studies on information processing; high-speed computing, data storage and machine tool control. Knowledge of digital techniques and experience in designing transistorized equipment will be particularly useful. The posts carry attractive and progressive salaries, combined with excellent conditions of employment, including superannuation and life assurance. Applicants should write to the Personnel Officer, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting ref. JHR. W 3111

OVERSEAS Oil Exploration Company with world-wide seismic parties offers permanent career to electronic technicians. Maintaining and operating field equipment. Men prepared to accept responsibility and to live in camp conditions. Academic qualifications to H.N.C. or equivalent and genuine practical experience to this standard. Liberal home leave. Box W 338.

PHYSICIST with experience in nuclear radiation measurements and development of electronic instruments required to take charge of Nuclear Engineering Laboratory. This is a senior appointment providing a wide field of interest on Reactor, Hospital and Industrial nucleonic instrumentation. The post is pensionable and carries a salary commensurate with the level of responsibility. Please write, in confidence, to the Chief Engineer and Manager, Nuclear Engineering Division, General Radiological Ltd., 15/18, Clipstone Street, London, W.1. W 3157

PLANNING ENGINEER required (age 30-40) for planning electro-mechanical and electronic machines. Must have O.N.C., in Electrical Engineering and several years' experience in light electrical production. Salary approximately £800 p.a., according to ability. Apply, Personnel and Education Manager, Powers-Samas Accounting Machines Ltd., Aurelia Road, Croydon, Surrey. W 1097

PLESSEY NUCLEONICS LTD., Northampton Junior Physicists. Applications are invited for a number of posts in the development laboratory of this Company. Successful candidates would work as members of a team engaged in the application of the techniques of nuclear physics to a wide range of problems. A degree in Physics is necessary and one or two years' experience of research or development work in similar fields would be an advantage. The Company offers attractive salaries and working conditions, and the positions will provide ample scope for advancement in this rapidly expanding industry. Applications to The Personnel Manager, Plessey Nucleonics Ltd., Weedon Road, Northampton. W 3103

PROGRESSIVE BIRMINGHAM ELECTRONIC ENGINEERING COMPANY require General Manager, Pension Scheme available, please state age and details of previous experience. Box No. W 1088.

PROTOTYPE ENGINEER required for high quality electronic instrument work. Successful applicant would have to work in small department and be responsible to head of section for engineering of prototype equipment, supervising to production stage, etc. Good opportunities for advancement and initiative. Write full particulars to Ultrasonoscope Co., Sudbourne Road, Brixton, S.W.2. W 3135

REPRESENTATIVE WANTED by company manufacturing high class transformers for industrial purposes. Quick promotion to Sales Manager if satisfactory. Must have a sound knowledge of electronics and previous sales experience. Please write fully and in confidence stating qualifications, experience, age and salary required. Box No. W 3143.

RESEARCH ENGINEER required in connecti on with production of components for radio-valve and television tubes at Aycliffe, near Darlington, Co. Durham. Ability to develop new ideas essential. Experience in high vacuum techniques and valve production definite assets. Applicant must be between 25 and 35 years and possess a degree or H.N.C. Excellent prospects in expanding organization. Contributory pension scheme. Write giving age and full detailed account of qualifications and previous experience to: Personnel Officer, Union Carbide Limited, Kemet Division, 103, Mount Street, London, W.1., quoting reference EE10. W 3141

SENIOR DESIGN DRAUGHTSMEN—Men with initiative and previous design experience in Electronics or Nucleonics are invited to apply in writing to 'The Chief Engineer', General Radiological Ltd., 15-18 Clipstone Street, London, W.1, stating age, experience, qualifications and salary requirements. W 3172

SENIOR DESIGN ENGINEER required with wide experience of the design of small transformers from milli-watts to 5KVA capacity. Full details of past experience, academical qualifications and salary envisaged. Permanent post with attractive pension scheme. Apply Woden Transformer Co. Ltd., Moxley Road, Bilston, Staffs. W 3161

TECHNICAL ASSISTANT required for servicing, calibrating and testing ultrasonic Flaw Detectors. Successful applicant will be expected to exercise a large measure of responsibility and initiative. Experience in pulse equipment desirable but not essential. Write giving full particulars to: Ultrasonoscope Co., Sudbourne Road, Brixton, S.W.2. W 3136

TECHNICAL ASSISTANT required in ultrasonic research laboratory. Varied work on a wide range of subjects. O.N.C. or Inter. B.Sc. standard in Physics or Electrical/Electronic Engineering preferred. Successful applicant would be encouraged to continue studies. Write giving full particulars to Ultrasonoscope Co., Sudbourne Road, Brixton, S.W.2. W 3137.

TECHNICAL AUTHORS. Required for Electronics Section. Good salaries and prospects. Written applications with full details age, experience, etc., to Personnel Manager, Marshall Airport Works, Cambridge, quoting TA/1. W 1093

CLASSIFIED ADVERTISEMENTS
continued on page 6

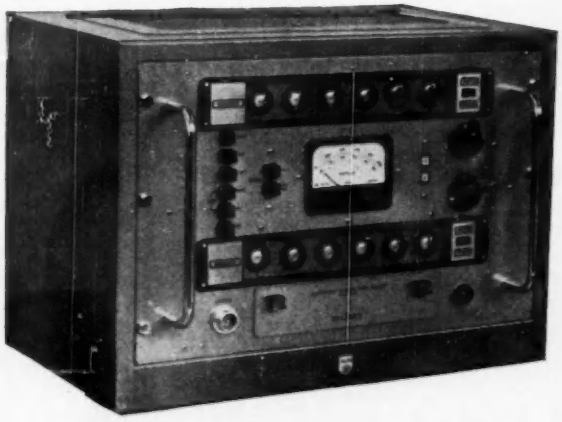
EKCO

nucleonics & electronics

information sheet

Type N530

AUTOMATIC SCALER



THE EKCO N530 Automatic Scaler is a combined Scaler and Timer which incorporates a stabilized high-voltage supply suitable for operating a G.M. tube or Scintillation Counter, an input amplifier and a pulse height discriminator. It can be used to time a predetermined count, to count for a predetermined time or as a manually-operated scaler.

With the addition of a suitable radiation counter it forms a complete counting and timing equipment.

specification

INPUT SENSITIVITY. Pos: 5V min., to Direct or Probe input. Neg: 0.1V to G.M. Input (5 microsecs. differentiating time constant).

INPUT RESOLUTION. 5 microseconds.

AMPLITUDE DISCRIMINATOR. Only pulses with amplitude above pre-set level are counted. Acceptance level is variable between 5–50V., and the voltage is shown on the meter. The discriminator operates directly for positive inputs of 5–50V., and after the input amplifier, for negative inputs.

SCALING CIRCUIT. The first two decades use hard valve scale-of-ten circuits; the other four, 'Dekatrons'. For uniformity of presentation, patented indicating tubes are used with the two fast decades.

TIMER. Presentation of time intervals up to 100,000 secs. (0.1 sec. units) by 'Dekatrons'. Timing unit operates on 50 or 60 c/s mains (as ordered) or, for greater accuracy, an external 50 or 60 c/s frequency may be used.

AUTOCOUNT. The scaler can be automatically stopped at these predetermined counts: 100, 300, 1,000, 3,000, 10,000, 30,000, 100,000, 300,000, 1,000,000. When the set figure is reached, the timer records elapsed period. Stopping time is about 2 milliseconds.

AUTOTIME. The scaler can be automatically stopped at a predetermined time, when the total count will be presented. Settings are: 100, 300, 1,000, 3,000, 10,000, 30,000, 100,000 secs. If Autocount and Autotime switches are both 'on' the scaler stops at the count or time reached first.

MANUAL OPERATION. The scaler works independently of automatic circuits when Autocount and Autotime are both 'off'.

TEST FACILITIES. A Mains Frequency test will check Count and Time circuits, and the stopping system. A 1 c/s test button checks the first decade sequence.

H.V. SUPPLY. Output voltage is variable over two ranges 250–1,000 and 500–2,000V. and is shown on the meter. Output current: 100 microamps up to 1,500V. decreasing to 10 microamps at max. voltage. Ripple, spurious pulses: less than 5 millivolt peak. H.V. supply may be switched off when not needed.

STABILITY. Mains voltage variations up to $\pm 10\%$ do not affect scaling and timing circuits. The timer is directly dependent on mains frequency unless an external standard is used. Stability of H.V. for mains voltage variations of $\pm$ 10% is $\pm$ 0.5%.

EXTERNAL SUPPLIES. Power is available at the 'Probe' plug for operating an Ekco N550, N559, or N509 Scintillation Counter, a G.M. Probe, or Quench Unit.

MAINS INPUT. 110–120V. and 200–250V. 50 or 60 c/s (as ordered). Consumption 130 watts.

DIMENSIONS. Complete in case 21″ x 15¾″ x 16¼″ deep. Weight 61 lb. Also to special order for rack mounting: 19″ x 12¼″ x 14″ deep. Weight 41 lb.

sales, installation and service

EKCO ELECTRONICS LTD

Ekco Works, Southend-on-Sea. Essex. Telephone: Southend 49491

SITUATIONS VACANT (Cont'd.)

TECHNICAL REPRESENTATIVE required to cover the Midlands area for a rapidly expanding Company manufacturing advanced servo equipment. Qualifications in electrical engineering essential and a knowledge of servo systems desirable. Car provided. Salary £1,100 to £1,300 per annum with good prospects. Reply Box No. W 3139.

W. D. & H. O. WILLS. Training to be computer Engineers. Opportunities exist for suitable applicants to become Computer Engineers. After a comprehensive training, lasting several months, the engineers will work in small teams on the maintenance of a large scale digital computer in the Bristol area. All applicants should possess Graduate, H.N.C. or equivalent qualifications in Electronics and preference will be given to those who have had some knowledge of pulse techniques. Applicants should also have had some previous experience of systems incorporating pulse circuitry, but a more important requirement is a facility for quickly grasping new principles. The positions are permanent and pensionable and good starting salaries will be offered to successful candidates, who should be under 30. Please send details of age, qualifications and experience to: Personnel Manager (Staff), W. D. & H. O. Wills, Bristol, 3. W 1086

WORKS MANAGER required for Electronic Engineering Company in S.W. London. Must be familiar with small batch production techniques associated with electronic control equipment and be capable of running an assembly and chassis wiring shop. Experience of transformer winding and electronic weld timers an advantage but not essential. Pension Scheme in operation. Write full details of experience and present salary to Box No. W 3162.

TELEVISION ENGINEER, junior grade, required for an interesting new programme of planning and development work on studio equipment. Commencing salary, £750 p.a. Pension Scheme. Apply Head of Television Broadcasting Department, Central Rediffusion Services Limited, Television House, London, W.C.2. W 3172

SITUATIONS VACANT Continued on p. 8

FOR SALE

DELAPENA High Frequency Induction Welding Units, type E.14., 10 & 7½ kW capacity. Whitefield Machinery & Plant Limited, Cobden Street, Salford, 6. Tel: Pen. 4746. W 1092

GUARANTEED MAGSLIPS at low prices, 3in. Resolver No. 5 (AP 10861), 50v, 50c/s. Unused, each in tin, 35s. post 2s. 1d. Large stocks of these and other types.—P. B. Crawshay, 94 Pixmore Way, Letchworth, Herts. Tel.: 1851. W 321

MAGSLIPS, SELSYNS and many other items connected with automatic and remote control mechanisms are marketed by Servo & Electronic Sales Ltd. Brochure available on request. See our display advertisement on p. 168. W 202

EDUCATIONAL

CITY AND GUILDS (Electrical, etc.) on "NO PASS—NO FEE" terms. Over 95 per cent successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook—FREE and post free. B.I.E.T. (Dept. 337c), 20 Wright's Lane, London, W.8. W 316

T.V. AND RADIO—A.M.Brit. I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "No Pass—No Fee" terms. Over 95 per cent successes. Details of Examinations and Home Training Courses in all branches of Radio and T.V. Write for 144-page handbook—Free. B.I.E.T. (Dept. 337H), 29 Wright's Lane, London, W.8. W 187

BUSINESS OPPORTUNITIES

MEASURING EQUIPMENT. Small group of companies establishing itself in nuclear field wishes to absorb company making nuclear measuring equipment whose management can remain to assist in group development. Factory space available. Write Box CC/40, c/o 95, Bishopsgate, London, E.C.2. W 3158

CAPACITY AVAILABLE

A COMPANY manufacturing magnetic relays are in a position to accept development, design and assembly work of complete units incorporating relays and uniselectors, etc., Box W 3102.

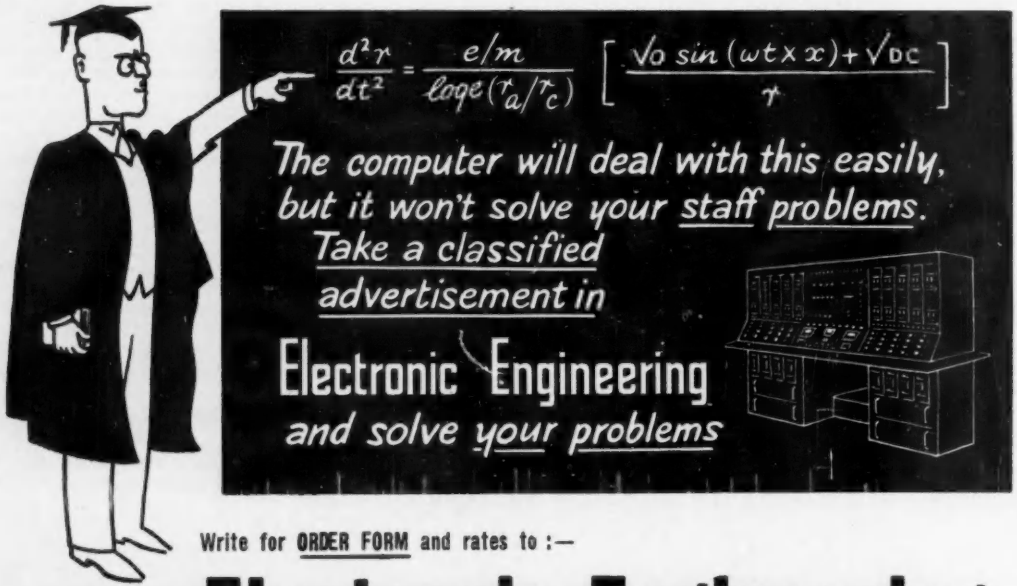
CONSTRUCTION, DEVELOPMENT AND TESTING of electronic equipment, including prototypes, immediately undertaken by small progressive company. Wiring and assembly inquiries invited. F. E. Porter & Sons (Electronics) Ltd., Holders Hill Road, Mill Hill, N.W.7. W 1096

SERVICE

GUARANTEED DELIVERY from Broxlea Products' new factory at Broxbourne. See page 78. W 3147

OPTICAL GRATICULES and other specialized Components for Optical Projection Electronic Instruments. Fidelity Instrument Co., Ltd., 284, Western Road, S.W.19 (MIT.2241) for design, development and batch production of optical/mechanical components of an intricate and precision nature. W 1083

TRANSLATIONS—Electronics, Physics and Electrical Engineering. Russian, German, Polish, Italian or Spanish to English. Quick service, estimates free. Box No. W 1100.


$\frac{d^2r}{dt^2} = \frac{e/m}{\log_e(r_a/r_c)} \left[\frac{\sqrt{o}\sin(\omega t \times x) + \sqrt{DC}}{r}\right]$
The computer will deal with this easily, but it won't solve your staff problems.
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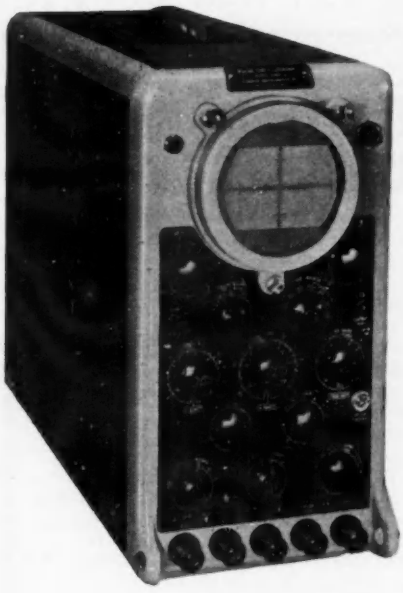
Electronic Engineering
and solve your problems

Write for **ORDER FORM** and rates to :—

Electronic Engineering

Advertisement Department 28, Essex Street, Strand, London, W.C.2. **Tel: CENtral 6565**



Thinking about an oscillograph?

Consider Model 1065

Designed for a wide variety of laboratory applications, it has a very interesting specification including:
Y amplifier of sensitivity 250 mV/cm with a bandwidth, d.c. to 20 Mc/s and rise-time better than 40 mμsec;
X amplifier: Time measurement by calibrated shift and internal oscillator for timing marks; voltage measurement by calibrated shift; probe providing an input impedance of 1.5 MΩ, 12 pF. We shall be pleased to send you full data on this and other equipment in the Cossor range.
An export model (1065X) is also available.

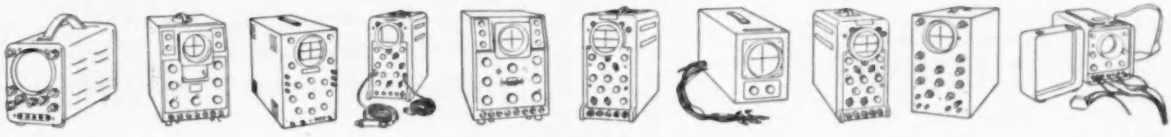
Write for information to:

If you are experienced in the design of high quality instruments, our Technical Director would be glad to hear from you.

COSSOR INSTRUMENTS LIMITED

The Instrument Company of the Cossor Group

COSSOR HOUSE, HIGHBURY GROVE, LONDON, N.5.
Telephone: CANonbury 1234 (33 lines). Telegrams: COSSOR, NORPHONE, LONDON. Cables: COSSOR, LONDON. Codes: BENTLEY'S SECOND



TAS/CI.3

COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF SUPPLY
WEAPONS RESEARCH ESTABLISHMENT
SALISBURY, SOUTH AUSTRALIA

Applications are invited for positions of Scientific and Experimental Officers in the Development of Instrumentation for the performance testing of Guided Missiles.

SCIENTIFIC OFFICER, GRADE 3 (Several Vacancies)

Duties: Research and development work associated with the performance testing of guided missiles and target aircraft, in the fields of:—
- (*a*) Problems of atmospheric optics associated with the performance of optical equipment under field conditions.
- (*b*) Servo-controlled aerial and camera mounts.
- (*c*) Transducers and allied equipment and techniques.
- (*d*) Telemetry systems.
- (*e*) Electronic and electro-mechanical devices used in the control of pilotless aircraft.
- (*f*) Analogue and digital computers.
- (*g*) Microwave techniques.

Qualifications: Honours Degree in Physical Science, Electrical or Radio Engineering desirable, or other academic qualifications and research achievements considered the equivalent. Research experience in the relevant field.

Salary Scale: £1,731/1,951 (Australian Currency).

SCIENTIFIC OFFICER, GRADE 1 (Several Vacancies)

Duties: Research and development associated with the performance testing of guided missiles and target aircraft, in the following fields:—
- (*a*) Radar and allied techniques.
- (*b*) Radio telemetry techniques.
- (*c*) Analogue and digital computers.

Qualifications: Honours Degree in Physical Science, Electrical or Radio Engineering. Research experience would be an advantage.

Salary Scale: £1,326/1,641 (Australian Currency).

EXPERIMENTAL OFFICER, GRADE 3)Several Vacancies)

Duties: Experimental and developmental work associated with the performance testing of guided missiles and target aircraft, in the fields of:—
- (*a*) Film processing techniques, including:—
  - (i) New methods of processing films at present in use;
  - (ii) Processing techniques for new types of film, including colour film.
- (*b*) Analogue and digital computers.
- (*c*) Electronic tracking systems.
- (*d*) Radar and allied techniques.
- (*e*) Centrimetric transponders and allied techniques associated with the navigation of pilotless aircraft.

Qualifications: Degree or Diploma in Physical Science, Electrical or Radio Engineering desirable or equivalent academic qualifications, and some experience in the relevant field.

Salary Scale: £1,506/1,686 (Australian Currency)

EXPERIMENTAL OFFICER, GRADE 1 (Several Vacancies)

Duties: Experimental and developmental work associated with the performance testing of guided missiles and target aircraft, in the fields of:—
- (*a*) Timing, programming and communication equipment associated with the operation of ground-based airborne cameras.
- (*b*) Specialised tracking mounts for cine cameras.
- (*c*) Measuring instruments associated with the study of atmospheric optics.
- (*d*) Electronic equipment for the control of pilotless aircraft.
- (*e*) Centrimetric transponders and allied techniques associated with the navigation of pilotless aircraft.
- (*f*) Analogue and digital computers.

Qualifications: Degree or Diploma in Physical Science, Electrical or Radio Engineering, or other academic qualifications and experience considered the equivalent.

Salary Scale: £1,056/1,416 (Australian Currency).

CONDITIONS:

Location: Successful applicants will be employed in the laboratories of the Weapons Research Establishment at Salisbury or Woomera. Salisbury is approximately 14 miles from Adelaide.

Housing: Assistance will be given in obtaining housing accommodation for officers and their families.

Travel: First-class passages by sea or air will be provided for successful applicants and their families (dependent wife and children) subject to the officer entering into a bond to remain in the Australian Commonwealth Public Service for a period of three years.

Application forms are available from:—,

The Senior Representative (A.V.7),
Department of Supply, Australia House, Strand,
LONDON, W.C.2.

with whom applications should be lodged by 10th November, 1958.

T SITUATIONS IN THE UNITED STATES

Transitron Electronic Corporation, one of the world's largest producers of semiconductors, offers responsible positions in its Research Development and Production staff in the United States.

Engineers or Scientists trained in physics, electrical engineering, electronics, metallurgy or chemical engineering will find unusual opportunities. Experience in semiconductors, vacuum tubes, capacitors, resistors or other components is helpful but not required.

Transitron will obtain preferential visas, pay for transportation to the United States and arrange for housing. Transitron's two plants are located in suburban Boston.

Company benefits include a guaranteed pension plan.

The Chief Engineer of Transitron will be in England for personal interviews in the near future. Engineers are requested to write to Transitron for an appointment. All replies will be held in strictest confidence.

Transitron electronic corporation

168 Albion Street, Wakefield, Mass., U.S.A.

Cable Address; TRELGO Wakefield, Mass., U.S.A.

FERRANTI LIMITED
DUNDEE

require

VALVE ENGINEERS

for development work on valves for pulsed operation involving new techniques.

Applications are invited from candidates with a Degree or Higher National Certificate in Electrical or Electronic Engineering and preferably with some experience.

Apply in writing to Personnel Supervisor, Ferranti Limited, King's Cross Road, Dundee.

THE DE HAVILLAND ENGINE COMPANY LIMITED

requires a

MECHANICAL ENGINEER or PHYSICIST

for work on Instrumentation—application and design—in connection with Gas Turbine Engines and Rocket Motors.

Applicants should be of H.N.C. or Degree standard, but appropriate experience in this field will be considered of equal importance.

Call on or write, quoting reference SC 784 to:

The Personnel Officer,
The De Havilland Engine Company Limited,
Stag Lane, Edgware, Middlesex.

SOLARTRON

CHIEF ELECTRONIC ENGINEER

Solartron Electronic Business Machines Ltd., Farnborough, Hants, is looking for a Chief Electronic Engineer with wide experience in leading research and development teams. This exceptional opportunity calls for considerable experience in the electronic data-processing field in the broadest sense. Applicants should have a thorough knowledge of basic physical theory in the electronic, optical and mechanical fields, and mathematical ability either in the field of analysis and transforms or of logical algebra. Proven ability in making an original contribution to the conception and design of new products and in electronic circuit design is essential.

Initial projects includes pecialised applications of analogue and digital techniques and character recognition.

To a man already earning at least £2,000 p.a. this appointment offers unusual scope and, in due course, the opportunity to play a leading part in making policy decisions.

SENIOR ELECTRONIC ENGINEERS

Stimulating atmosphere, encouraging creative ability.

Rapid advancement on ability, and effective contribution.

Informal personal relationships, small group organisation structure.

Maximum delegated responsibility at all levels.

Secure career opportunities.

These are a few of the reasons for the success of one of the most rapidly expanding companies in this country.
Opportunities exist for YOU at Dorking, Surrey; Farnborough, Hants; Thames Ditton, Surrey—in the following fields.
Advanced instrumentation, analogue computers, Character recognition, Data recording, digital techniques, industrial controls, radar simulation.

WHY NOT DISCUSS YOUR FUTURE CAREER WITH US?

Please apply in writing to:

The Group Personnel Officer,

THE SOLARTRON ELECTRONIC GROUP LTD.

Thames Ditton, Surrey

FERRANTI LIMITED

Wythenshawe,
MANCHESTER

BLOODHOUND

Guided Weapons

Vacancies exist at all levels for qualified men to take part in important developments of the "Bloodhound" guidance and control systems.

Experience in one of the following fields is desirable, and essential for the senior posts.

Radar Techniques
Digital Computers
Control Systems and Servo-Mechanisms
Electro-Mechanical Instruments
Operational Analysis
Transistor Applications

The minimum qualifications are an ordinary degree in Physics, Engineering or Mathematics, or a Higher National Certificate. Salaries, which are reviewed annually, will be in the range £600 to £1,500 according to qualifications and experience.

The laboratories are housed in a modern building pleasantly situated on the Cheshire boundary with easy access to rural areas. The Company has a Staff Pension Scheme and an Insurance Scheme for Dependants.

Forms of application can be obtained from:-

T. J. Lunt, Staff Manager,
FERRANTI LIMITED, HOLLINWOOD, Lancs.

Please quote reference DB.

TECHNICAL WRITER

required by Company now extending its range of nucleonic instruments. Knowledge of Electronics desirable.

Salary in accordance with experience.

Opportunity of advancement.

Apply : Personnel Officer,

ISOTOPE DEVELOPMENTS LIMITED,
Beenham Grange, Aldermaston,
Nr. Reading, Berks.

ELECTRONIC DEVELOPMENT ENGINEER

Hilger and Watts Limited, invite applications for the above post from graduate Electrical Engineers or graduates in Physics with a sound knowledge of Electronics.

The successful applicant will be required to work on the design and development of electronically controlled spark generators to be used in the automatic analysis of metals, and should preferably have had some practical experience in the use of High Voltage and Radar Pulse techniques.

The post offers considerable scope in a progressive organisation with an international reputation.

Applications giving all relevant details should be addressed to:-

The Chief Personnel Manager,

HILGER & WATTS LIMITED
98 ST. PANCRAS WAY, LONDON, N.W.1

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

INDUSTRIAL GROUP

ELECTRONIC MECHANICS

Windscale and Calder Works require experienced men with knowledge of electronic equipment for fault diagnosis, repair and calibration of a wide range of instruments used in nuclear reactors, radiation laboratories and chemical plant. This interesting work involves the maintenance of instruments using pulse techniques, wide band and noise amplifiers, pulse amplitude analysers, counting circuits and television.

Men with Services, Industrial or Commercial background of Radar, Radio or Television are invited to write for further information. Training in our Instrument School will be given to successful applicants.

Married men living beyond daily travelling distance will be eligible for housing after a short period of waiting. Lodging allowance is payable during this period. Working conditions and promotion prospects are good.

Applications to:

Works Labour Manager,

United Kingdom Atomic Energy Authority
Industrial Group
Windscale and Calder Works, Sellafield,
Seascale, Cumberland

FERRANTI LTD.

West Gorton, MANCHESTER

has a vacancy for a

TECHNICAL WRITER

in their

Computer Department

Applicants should have the ability to express themselves clearly and possess a knowledge of electronic engineering up to at least H.N.C. standard. A formal qualification is not essential.

This appointment will offer a unique opportunity for keeping abreast of the latest digital computer engineering techniques. It carries a salary fully commensurate with age, experience and responsibility. The Company operates a Staff Pension Scheme and a Dependants Insurance Scheme.

Application forms can be obtained from T. J. Lunt, Ferranti Ltd., Hollinwood, Lancs. Please quote ref. KL.W.

KELVIN & HUGHES LIMITED

New North Road, Barkingside, Essex.

invite applications for

POSITIONS IN THEIR RESEARCH LABORATORY

for work in connection with Ultrasonic investigation.

Candidates should possess Higher National Certificate in Metallurgy or have had equivalent experience.

A vacancy also exists in the same department for an **ELECTRONIC DESIGN ENGINEER** who will be required for development work on electronic circuits used in the examination of engineering materials. Candidates for this post should possess Higher National Certificate, preferably in light current, or have had equivalent experience.

Advanced rates of pay and conditions of employment. Medical and canteen facilities available. The establishment is served regularly by both tube train and bus services.

Applications should state qualifications, experience, age and salary required to the Personnel Manager, quoting Ref. F.3422.

Plessey

Research Opportunities in a Growth Industry

The Plessey Company announce three excellent research opportunities for experienced graduates for newly created posts in their Central Research Organisation in the South Midlands.

These posts, which have been created in view of the expansion policy of the Company, offer a real challenge to able men desiring to work hard and make progress in a scientifically interesting and progressive Research Establishment. All posts carry membership of the Company Pension Scheme.

(a) **Senior Mechanical Engineer** **Salary in the region of £1,750**

The Senior Mechanical Engineer will rank as a Research Leader in the Organisation. He should have had experience in light engineering, preferably in connection with a development laboratory and be able to design apparatus of a pilot plant nature working directly from information obtained from the laboratory bench. The work ranges over the fields of chemistry, physics, metallurgy, powder technology, chemical engineering and electronics and hence demands a man of wide experience, able to make an engineering proposition out of a device developed by the laboratory scientist. He will liaise with other organisations in the Company and help to solve problems where his knowledge and experience are applicable.

(b) **Senior Electronic Engineer** **Salary in the region of £1,750**

The Senior Electronic Engineer will rank as a Research Leader in the organisation. He should be experienced in the adaptation of new components to circuits and will liaise with various Company organisations in order to introduce components into various applications. He will advise the Research Laboratory on future component requirements and familiarise himself with all developments in this field.

(c) **Manager for a Chemical Plant making Ultra-Pure Materials for the Electronic Industry** **Minimum Salary of £1,750**

A man with wide experience of chemical engineering plant and able to organise staff and labour is required. Experience with low temperature work (refrigeration and distillation), vacuum technology, gaseous decomposition and the handling of pure materials by chemical processes is desirable.
This is a particularly exacting and challenging post demanding a combination of high scientific and managerial ability and wide experience. It offers a really big opportunity to the right man.

Applications, stating age, experience and qualifications, to A. M. Brown, Esq., Executive Director (Personnel), The Plessey Company, Ilford, Essex.

N.B.—Please endorse your application and envelope Plessey A, Plessey B or Plessey C, indicating the post for which you wish to be considered.

BELL PUNCH COMPANY LTD.
of Uxbridge, Middlesex

have a further vacancy for a

Senior
ELECTRONIC ENGINEER

for Design and Development work on a large scale special-purpose Electronic Digital Computer.

Candidates should possess a good Engineering, Scientific or Physics degree (or equivalent qualification); must have had experience on the design of Electronic Digital Computer Circuits, and have a sound knowledge of low-power pulse techniques.

The Company's forward programme is substantial and a good salary with excellent prospects for advancement is available to the successful candidate.

Men with these qualifications are invited to telephone Mr. H. Danson at Uxbridge 8211 any weekday except Saturdays, when arrangements will be made for a personal interview at a mutually convenient time; alternatively, written application may be made.

W 3131

RADIO AND ALLIED INDUSTRIES LIMITED

(Sobell and McMichael)

have vacancies for a number of

Senior and Junior Development Engineers

for home and export television receiver development transistor circuitry work and AM/FM receiver design. Applicants for the Senior positions should have several years of successful design experience preferably also professional qualifications or university degree. These appointments provide an excellent opportunity for progressive engineers to join a successful and rapidly expanding organisation. There is a pension scheme and other amenities.

Applications should be addressed to Chief Engineer at Wexham Road, Slough, Bucks.

AN ATTRACTIVE OPPORTUNITY

has arisen for a

SENIOR ELECTRONIC ENGINEER

at

COTTAGE LABORATORIES LIMITED

Portsmouth Road, Cobham, Surrey

Applicants must be capable of leading a section carrying out advanced circuit design and development using the latest valve and transistor techniques, and taking designs to pre-production prototype stage.

The position is permanent and pensionable with good prospects of advancement from a starting salary in the range £1,100 to £1,400. The work is important and interesting and is carried on in a congenial atmosphere and with highly competent and progressive colleagues.

Five-day week and all the amenities you would expect to find in a sound well-established company.

The Chief Engineer would be glad to discuss this opportunity with you in strict confidence. Write to him at the above address or telephone Cobham 3191.

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required by European company specializing in electronics and electro-mechanical instruments. Reside Western Europe. Selling to laboratories and research groups.

Requirements: 1. Graduate Engineer essential.
2. Age 28 to 35.
3. Previous sales experience helpful.
4. One or more foreign languages desired.
5. Strong administrative and sales ability necessary.

Write to Box No. W.3142 including full résumé of background and salary requirements.

ELECTRONIC ENGINEERS

Senior and Junior Electronic Engineers are required for interesting and varied work in the Nelson Research Laboratories, English Electric Company Limited, Stafford. Applicants should have sound workshop experience and knowledge of Drawing Office procedure. Qualifications at least O.N.C. or equivalent.

Duties will involve responsibility for the engineering design of prototype electronic equipment from the rough circuit stage to the issuing of manufacturing information to the Laboratories' Workshops.

These posts offer ample scope for advancement to men with initiative and ability. Salary according to qualifications and experience.

Please write giving full details to Dept. C.P.S., Marconi House, 336/337 Strand, W.C.2, quoting reference EE 906K.

HEAD

of TRANSISTOR and

DIODE DEVELOPMENT LABORATORY

The Olivetti Company of Italy has established, in Milan, a subsidiary for the production of silicon and germanium transistors and diodes and is now looking for the "right person" to head the development laboratory which is already in existence.

If you are interested in working with this group, and are willing to move to Italy, please write, giving the fullest possible information to:-

Ing. C. Olivetti & C. S.p.A.,
(Project T.D.L.),
Ivrea, Italy.

The successful applicant would be expected to bring to this new firm fairly well-defined ideas on the development of transistor manufacture in Europe. He would be expected to contribute to policy formation in the firm. Applicants should be between 35 and 45 and have spent not less than 5 years in transistor development; have the degree M.Sc. (Physics); and be willing to learn Italian.

Salary will be commensurate with ability and experience, and the expenses of moving to Italy will be met by the firm.

Applications must be submitted not later than twenty days from the appearance of this advertisement. All applications will be acknowledged.

Interviews will be in London.

Opportunities in U.S.A.

for

ENGINEERS & SCIENTISTS

Westinghouse Electric Corporation is seeking a few highly qualified and experienced engineers to work in their large vacuum tube plant and laboratory in the beautiful Finger Lakes district of New York State.

Work assignments will be either in the field of microwave tubes or electron image tube devices, but engineers and scientists who have demonstrated ability in any branch of free electron science are encouraged to apply. High academic qualifications in physics or electrical engineering are also required. Salaries will be commensurate with these attainments and equivalent to $3,000 to $5,000 p.a.

Selected candidates will be interviewed in London in the near future by Dr. Hilary Moss, English born Westinghouse fellow engineer, who will be able to discuss from personal experience, all aspects of employment opportunities and migration to the U.S.

Applications accompanied by copies of, or references to, any relevant published work, should be sent to the Employment Manager, Westinghouse Electric Corp., Dept. M-4E, Box 284, ELMIRA, N.Y., U.S.A.

Westinghouse
ELECTRONIC TUBE DIVISION ELMIRA, NEW YORK

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AERODYNAMICS

The Weapons Research Establishment of the Department of Supply, Salisbury, South Australia, invites applicants for the position of:-

SCIENTIFIC OFFICER, GRADE 1.
(Temporary Position No. 91)

from Honours Graduates in:-

Physics or Electrical Engineering (including Electronics)

SALARY: £1,326/1,641 (Australian Currency).

DUTIES: Research associated with the development of special electronic instruments for aerodynamic research in wind tunnels and free flight.

LOCATION: Salisbury, which is situated sixteen (16) miles from Adelaide, the capital city of South Australia.

Whilst the position is classified as temporary, the tenure of employment is not limited, and after a specified period the appointee will be able to apply for entry to the Commonwealth Superannuation Scheme.

Under specified conditions, first class boat fare for the appointee and dependants (wife and dependent children) will be paid by the Commonwealth.

Housing accommodation will be made available.

APPLICATION FORMS AVAILABLE FROM:

The Senior Representative, (A.V.4), Department of Supply, Australia House, The Strand, LONDON, W.C.2.

with whom applications should be lodged by 10th NOVEMBER, 1958.

REGENTONE

THE REGENTONE GROUP OF COMPANIES have a number of senior and junior vacancies for engineers and draughtsmen in the laboratories of the manufacturing division.

Applicants should have experience in the fields listed below and be fully acquainted with modern techniques, including printed circuits.

TELEVISION R.F./I.F. development; General Circuit development, T.V. Tuners.

RADIO General radio design; production engineering of radio receivers.

DRAWING OFFICE Mechanical development of radio and television apparatus; detail drawing circuit diagrams, printed circuit masters and layouts.

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These are permanent and progressive posts and offer excellent opportunities in a modern and expanding concern. APPLY IN WRITING, stating age, experience and salary required to TECHNICAL DIRECTOR, Regentone, Eastern Avenue West, Romford, Essex.

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COMMISSIONING ENGINEERS for setting up Computers and auxiliary devices to operate satisfactorily in the production department and subsequently on sites in this country and abroad. Applicants should have either a degree (or equivalent) or suitable experience in the field of Digital Computers. (Ref. DCI).

SUPERVISING ENGINEERS for post installation service to Ferranti Computers in this country and abroad. Applicants should have technical knowledge up to H.N.C. standard or equivalent, whilst experience with Service electronic equipment would be an advantage. (Ref. DCM).

The above appointments will carry salaries fully commensurate with qualifications and experience. The Company operates a Staff Pension Scheme and a Dependants Insurance Scheme.

Application is by form, obtainable from T. J. Lunt, Staff Manager,

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The appropriate reference should be quoted.

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(ELECTRONIC)

are required for

interesting maintenance work at the

DOUNREAY EXPERIMENTAL REACTOR ESTABLISHMENT

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CAITHNESS, SCOTLAND.

Applications are invited from men with a fundamental knowledge of radio, radar, television or general industrial instruments and who have served a recognised apprenticeship or have had equivalent acceptable training.

Rate of pay is £11 14s. per 5-day, 44-hour week.

Accommodation will be provided for successful applicants recruited from beyond daily travelling distance of the Establishment. Married men will be eligible for housing and may also qualify for a lodging allowance.

Applications should be made to—

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The rapidly expanding Solartron Electronic Group invites technical writers, of the highest calibre, to join a team which aims to produce technical literature of a quality to match the Group's products.

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to work on **SERVOMECHANISMS**

for novel types of airborne instrument systems.

Senior Engineers should have a Degree, H.N.C., or equivalent qualification, and several years' research and/or development experience.

Junior Engineers should have O.N.C. or equivalent qualification and, preferably, some laboratory experience.

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E.M.I. International Ltd., the company which is responsible for development of recording methods and equipment for world-wide use by E.M.I. (H.M.V., Columbia etc.) at home and by E.M.I. associate companies abroad, offers a unique opportunity in its Record Engineering Development Department for an Acoustics Engineer.

The department has recently moved into spacious new laboratories at Hayes, in which work can proceed smoothly under ideal conditions. It is exceptionally well provided with modern measuring and testing equipment, much of which has been developed and made within the department.

The successful candidate would be given every opportunity to study all aspects of recording before specialising in the acoustics field.

The post involves the measurement of the acoustics of halls, studios and listening rooms at home and abroad, and the preparation of specifications for acoustic treatment thereof. It also affords opportunity for original work in the development of new methods and equipment for the evaluation of the acoustics and sound insulation of buildings.

Candidates should preferably have an honours degree in Physics and an interest in acoustics, electronics and music. Attractive salary and superannuation scheme. Apply giving details of qualification, age, etc. to:-

Personnel Dept., E.M.I. Ltd.,
Hayes, Middlesex.

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having about two years' experience in either of the following:

(a) Electric circuit design preferably including electric wave filters.

(b) Micro-waves.

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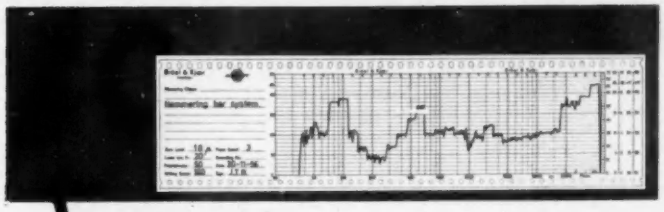

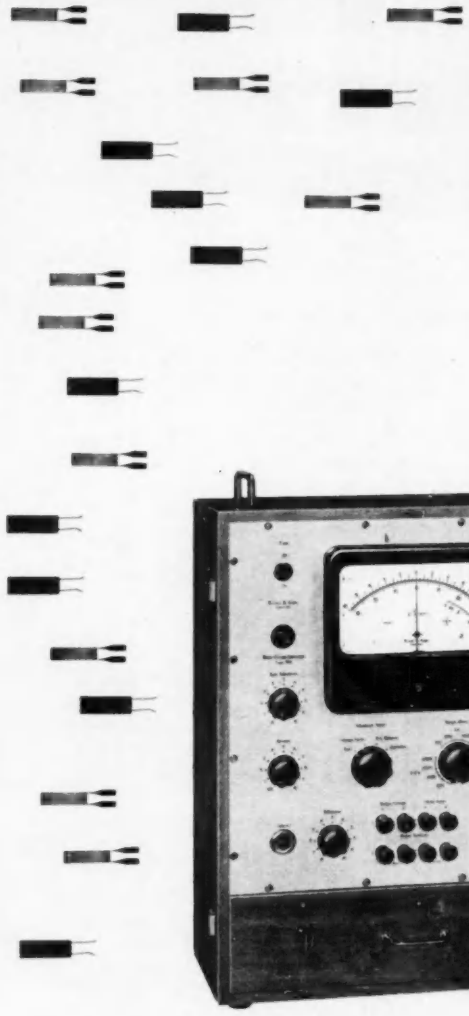

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The complete strain measuring systems developed by Brüel & Kjær therefore have been welcomed by industries and research laboratories all over the world and are now in use in most countries.

These systems enable the accurate recording of static strain measurements at up to 50 points automatically (see figure below).

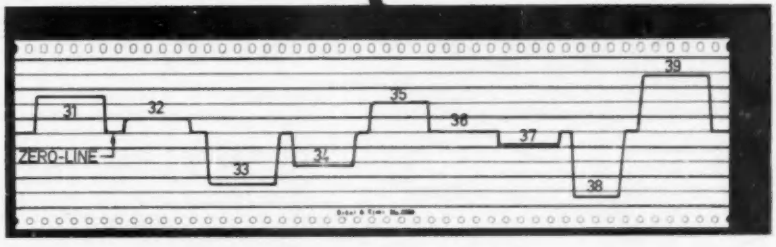
Furthermore, dynamic strain measurements can be made in the frequency range 0-100 kc/s, with complete frequency-amplitude diagrams of the strain being recorded on preprinted, frequency calibrated recording paper (see figure on top)

The systems are built-up of compact units which make them well suited for use in the field as well as in the laboratory. The main unit is the Strain Gauge Apparatus Type 1516 itself, a photo of which is shown to the left.

Write or phone for further information.

The B&K strain measuring systems feature:

1. A wide range of strain gages applicable
2. Direct indication in μ-strain
3. Direct indication of compression and tension.
4. Very high sensitivity (25 μ strain full deflection).
5. Insensitivity to hum and noise.
6. Automatic recording of multipoint measurements.
7. Automatic recording of dynamic strain spectrograms.



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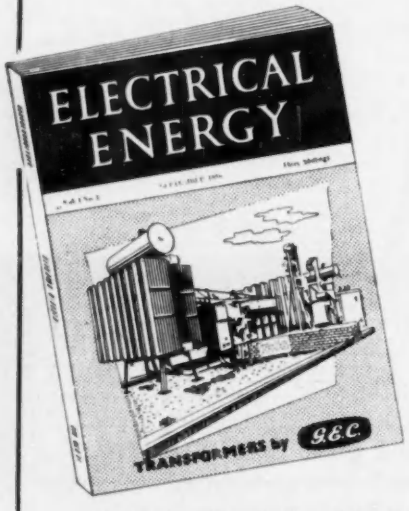

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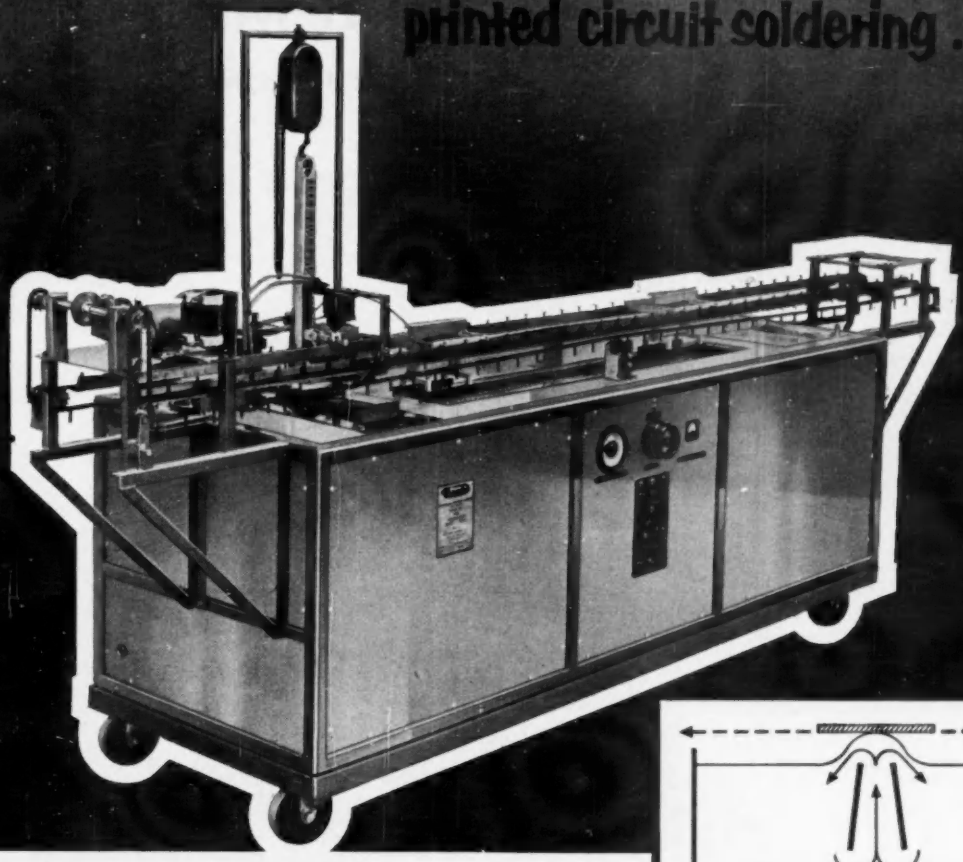

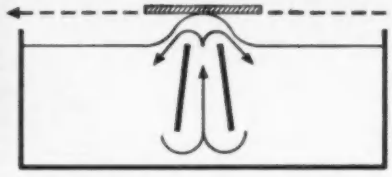

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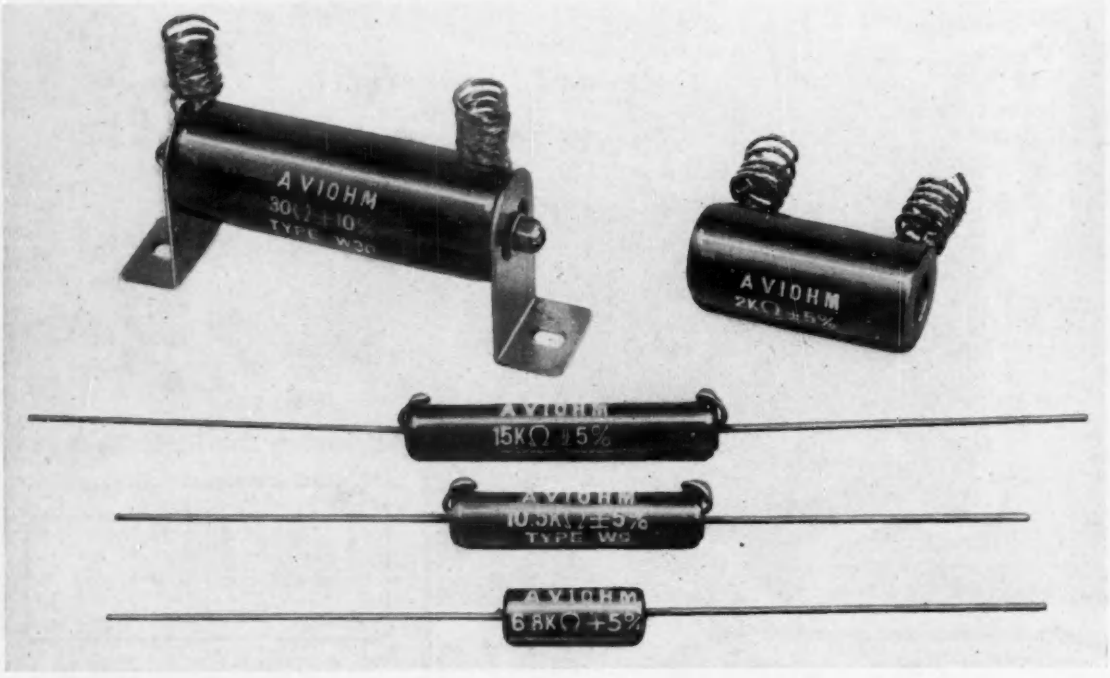

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Ohmic Values: 1 ohm—50,000 ohms.
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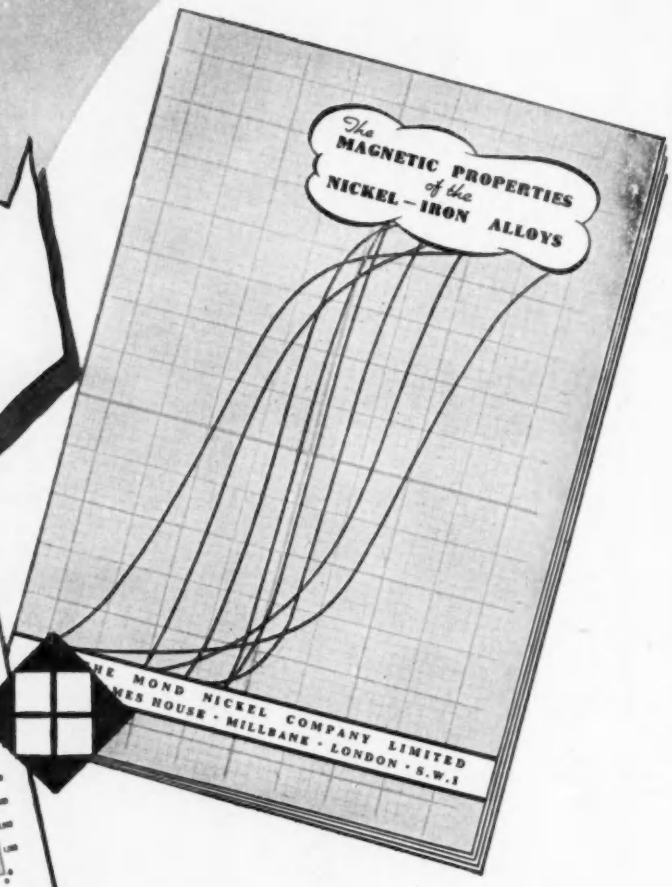

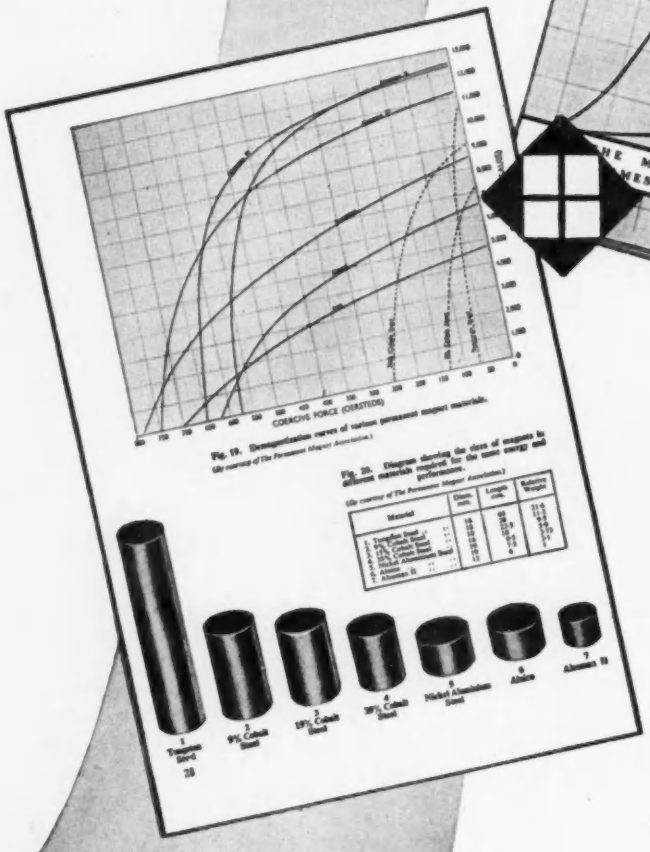

Nickel alloys provide for the designer a range of materials with a wide variety of magnetic properties. These include, on the one hand, the "soft" magnetic alloys, amongst which are found the highest permeabilities ever reported, and, on the other hand, steels which are sensibly non-magnetic.

A further group contains the most powerful permanent-magnet materials known, whilst yet another class provides the optimum properties for applications depending on magnetostrictive effects.

The high level of magnetic properties not only permits economic advantages, in saving the bulk and weight in equipment, but makes possible technical performance unattainable with other materials. Further advantages may often be realised in improved corrosion-resistance compared with that of other ferro-magnetic materials.

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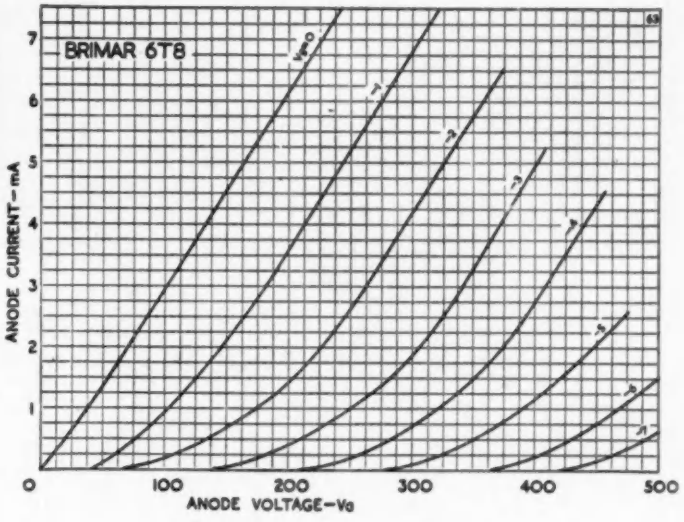
The Brimar 6T8 is a triple-diode-triode in which one diode has a separate cathode. The triode section has a high amplification factor making the valve suitable for use in AM/FM receivers in the demodulation and first stage audio circuits. The diodes may be used in series shunt limiter circuits, for example, in the audio sections of television and communications receivers, followed again by the triode section for A.F. amplification.

Near Equivalents
EABC80
DH719
6AK8



Typical Triode Operating Characteristics as an R.C. coupled amplifier.

Heater Voltage		6.3 volts
Heater Current		0.45 amp.
Anode Supply Voltage	250	250 volts
Anode Load Resistor	0.25	0.25 megohms
Grid Resistor	1.0	10 megohms
Cathode Bias Resistor	3	0 kilohms
Peak Output Voltage	43	40 volts
Stage Gain (for 24 V peak to peak output) ...	42	42
Distortion (for 24 V peak to peak output) ...	1	5%

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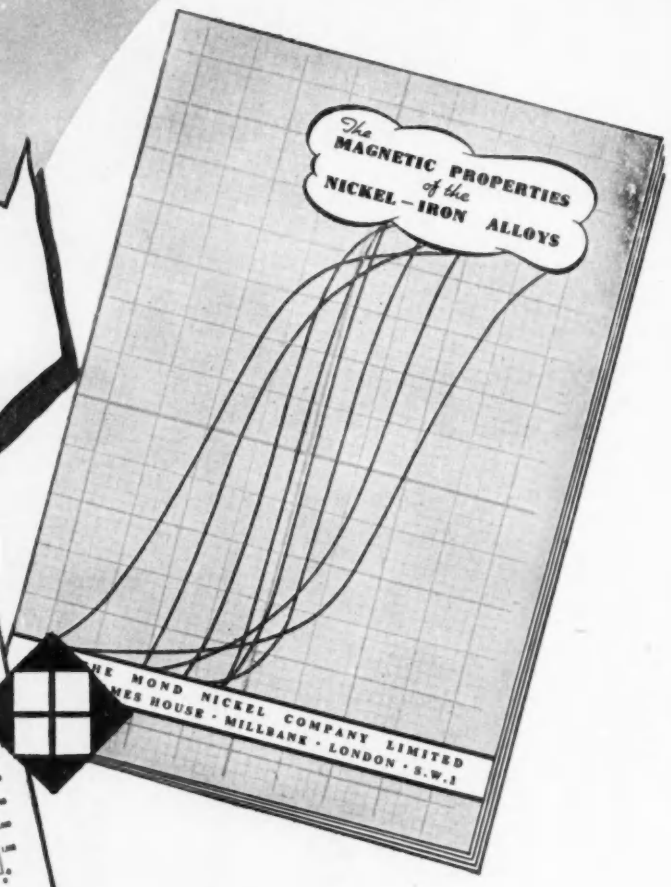

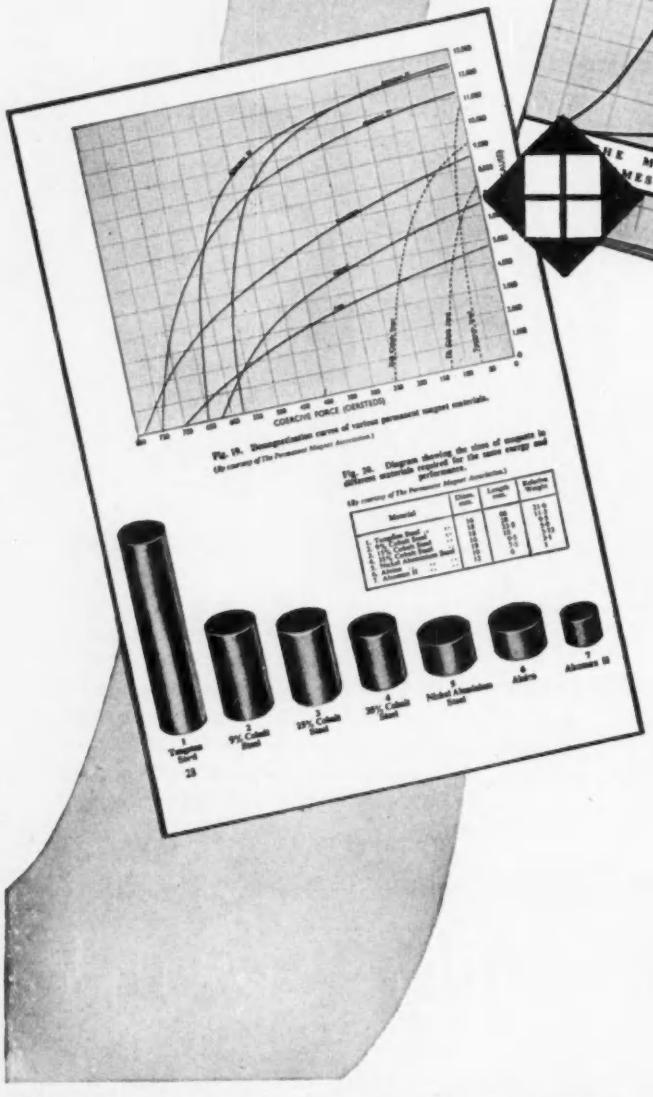

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DH719
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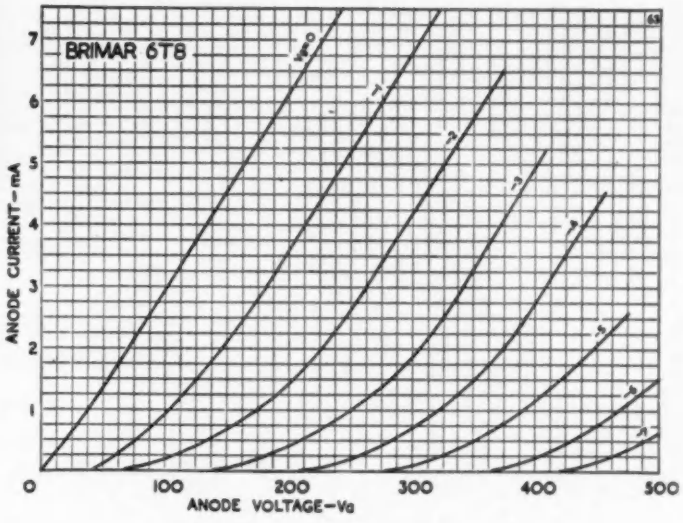

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Peak Output Voltage	43	40 volts
Stage Gain (for 24 V peak to peak output) ...	42	42
Distortion (for 24 V peak to peak output) ...	1	5%

Cut this out for further reference or write to the Publicity Department at Footscray for a data sheet.

Name .....

Address .....

EE

Standard Telephones and Cables Limited

Regd. Office : Connaught House, 63, Aldwych, London, W.C.2

FOOTSCRAY · SIDCUP · KENT · *FOOtscray 3333*

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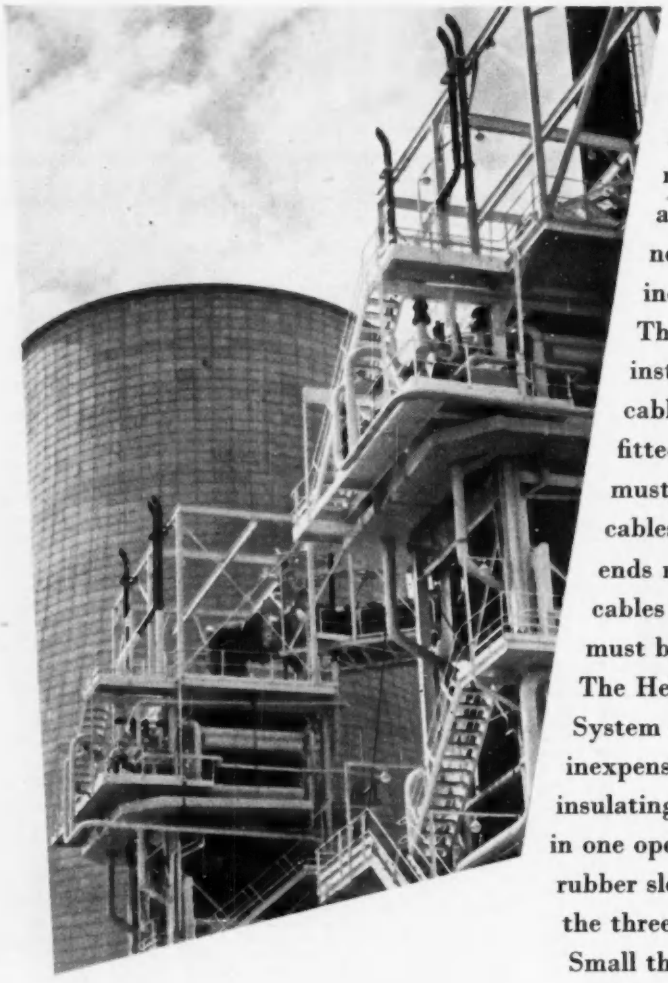


In this age of nuclear energy and automation, small things still count. Huge installations become more and more complex, and as rapidly as they grow the need for attention to detail increases.

The weakest point of any installation is the end of its cables and wires. When fitted with terminals the cable must be re-insulated; if braided cables are used the unravelled ends must be bound; individual cables in a complex wiring system must be readily identifiable.

The Hellermann Cable Binding System offers a quick, neat and inexpensive method of binding, insulating and identifying cable ends in one operation, by fitting plastics or rubber sleeves under tension with the three-pronged Hellermann tool.

Small things, indeed—but big undertakings *depend* on them.

Hellermann Limited

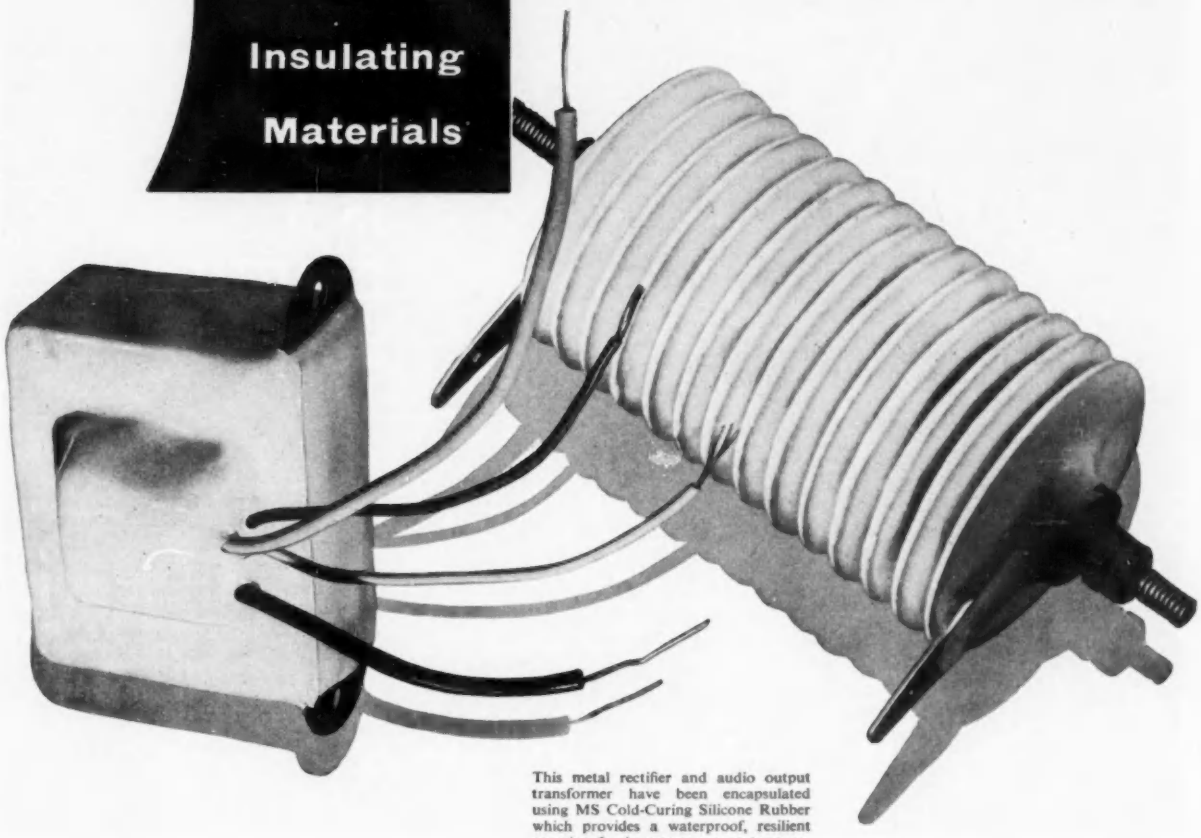
CRAWLEY SUSSEX ENGLAND

A SUBSIDIARY COMPANY OF BOWTHORPE HOLDINGS LIMITED

MS

Silicone Electrical Insulating Materials

MS Cold-Curing Silicone Rubber



This metal rectifier and audio output transformer have been encapsulated using MS Cold-Curing Silicone Rubber which provides a waterproof, resilient covering for long-term use at temperatures up to 200°C.

MS COLD-CURING SILICONE RUBBER

– Needs no heat to cure it. The addition of a catalyst is all that is required to cure at room temperature. The curing time may be varied from a few minutes to several hours according to the proportion of catalyst added.

– Possesses the excellent dielectric properties, heat endurance and high thermal conductivity associated with silicone rubbers. The material retains its resilience at both high and low temperatures and has excellent resistance to weathering and oxidation.

– Opens up new fields for designers. It can be used by unskilled operators to fill voids round lead wires of coils and motors, for impregnating coils, and for other similar sealing or potting applications. It is also used for making flexible moulds in which epoxide resins are cast.

– *Write for full information to:*

Other Electrical Insulating Materials employing MS Silicones include:

SILICONE COATINGS FOR RESISTORS | SILASTOMER COATED GLASS BRAID FLEXIBLE SLEEVING | SILICONE RESIN BONDED GLASSCLOTH LAMINATES

TYPICAL PROPERTIES OF MS COLD-CURING SILICONE RUBBER

Tensile strength lb/sq.in.	450	Permittivity at 1 Mc/s	3.20
Electric strength, on 10 mil sample, ¼ in. electrodes at 20°C instantaneous value, V/mil	400	Power Factor, at 1 Mc/s	0.006
		Volume Resistivity ohm.cm.500 Volts d.c.	1.5×10^{14}

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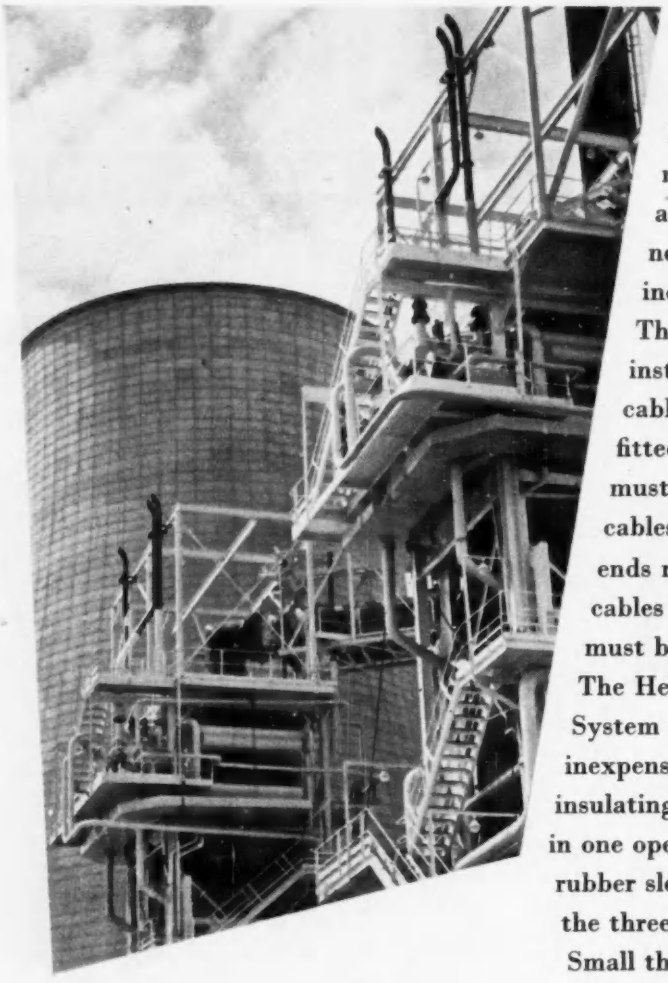

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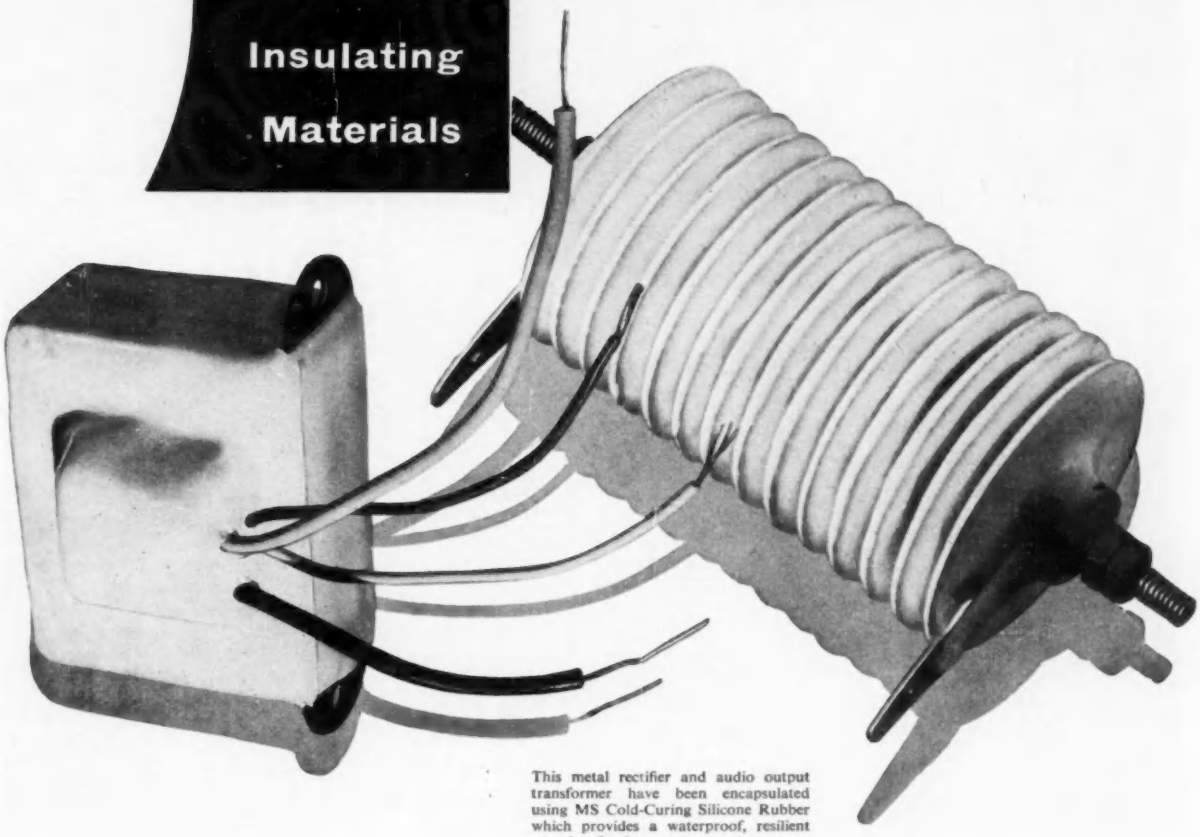
MS
Silicone Electrical Insulating Materials

MS Cold-Curing Silicone Rubber



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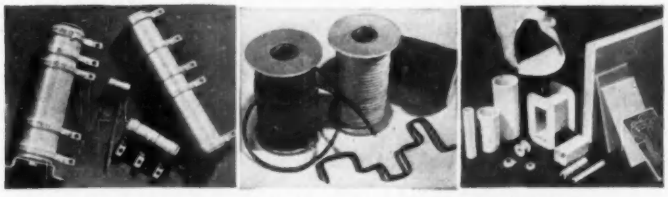

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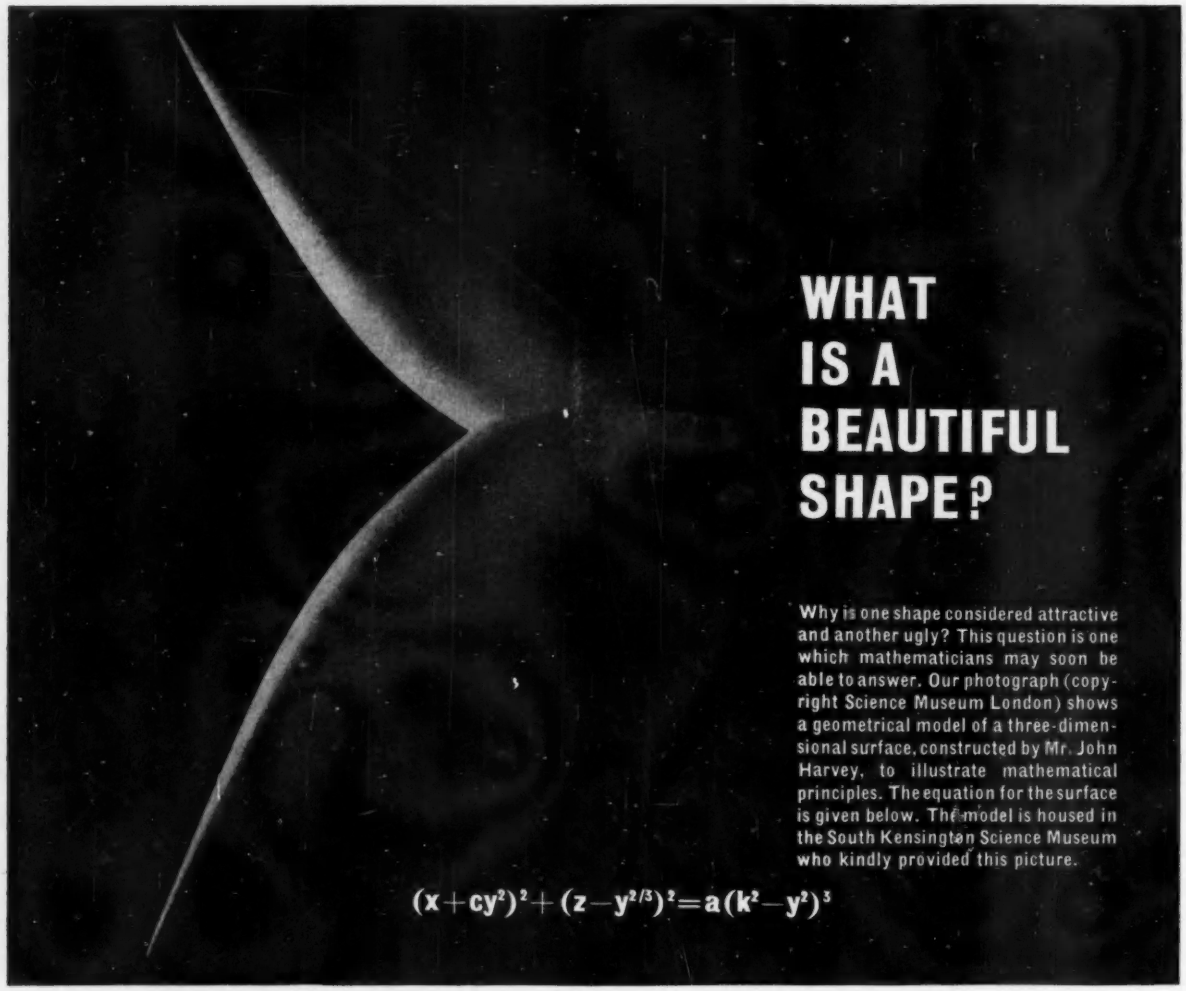

WHAT IS A BEAUTIFUL SHAPE?

Why is one shape considered attractive and another ugly? This question is one which mathematicians may soon be able to answer. Our photograph (copyright Science Museum London) shows a geometrical model of a three-dimensional surface, constructed by Mr. John Harvey, to illustrate mathematical principles. The equation for the surface is given below. The model is housed in the South Kensington Science Museum who kindly provided this picture.

$$(x+cy^2)^2+(z-y^{2/3})^2=a(k^2-y^2)^3$$

Shaping the course of industry is one of the mathematician's main pre-occupations today. Technological progress poses increasingly complex problems, demanding the highest mathematical skill and the very best computers. Which ? . . . for major problems—electronic computers of course. For all other purposes the CURTA—the personal calculating machine that is fast becoming the constant companion of mathematicians, scientists and technicians everywhere.

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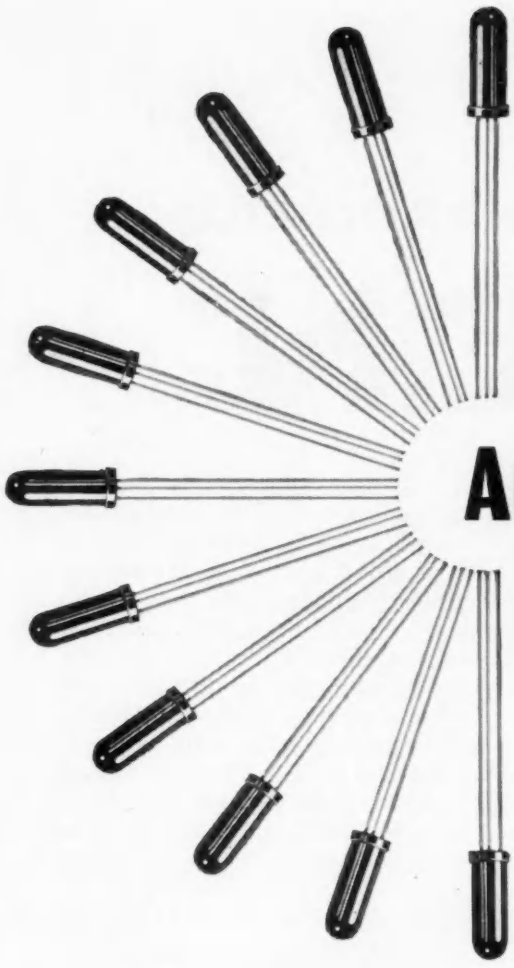

In quantity production and available now for industrial applications

NEW High Gain Audio Transistor OC75

gives you more than you had before

The new general purpose audio transistor OC75 gives you more gain than earlier types and its large scale production gives you the assurance of immediate availability. It is a high current gain development of the widely used OC71 and its α' range is from 60 minimum to 130 maximum at 3mA collector current.

Transistors OC70 and OC71 will, of course, remain fully available for those instances where the characteristics of a lower current gain stage are required. The present family of 3 types, the OC70, OC71 and OC75, each with a comparatively narrow range of α' spread, therefore covers all designers' requirements for low level audio amplifiers, low power low speed switching, low power non-linear applications, industrial control and interlock circuits and the many applications in which general purpose audio transistors are used.

Write to the address below for full data on the OC75 and other Mullard transistors.

Abridged Data

Typical current gain with grounded emitter (α')	90
Maximum voltage, d.c. (V)	−20
Maximum voltage, peak (V)	−30
Maximum collector dissipation at 45°C (mW) ...	75
Maximum junction temperature ... ... (*continuous operation*)	75°C
Maximum junction temperature ... ... (*intermittent operation—total duration 200 hours max.*)	90°C

MULLARD LIMITED
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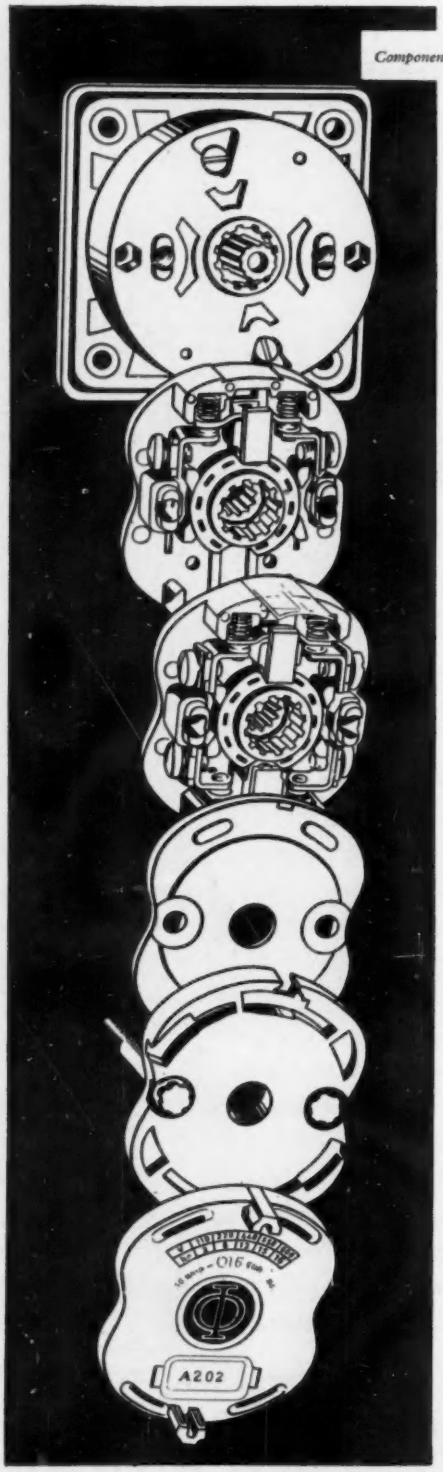
See Mullard transistors and diodes on Stand 2 at the ELECTRONIC COMPUTER EXHIBITION Olympia 28th. Nov. to 4th. Dec.

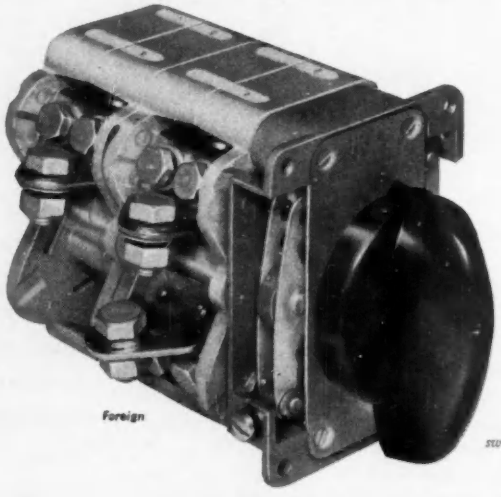
MIS2



Components of 16 amp switch with up to 18 latching positions

STANDARDIZED TO THE Nth DEGREE

Style C-Switches are standardized to an extent never previously achieved in switch design. Perfection of moulding permits each switch to be built up from a series of prefabricated sub-assemblies. By using appropriate operating cams, any practical contact arrangement can be provided by standard units, so that prices are kept low. Each contact unit carries two double-break silver alloy contacts, and any number up to twelve stages can form a single column; additional stages to be operated by the same control are arranged as extra columns, and are operated in tandem. Switches of different carrying capacities may be coupled if required. Escutcheon plates and control handles are common to the whole range. These switches are available in five ratings, from 16 to 200 amp at 600 volts a.c.



Foreign

200 amp 12 position switch for panel mounting

style C-switches

Full particulars from the Distributors for the United Kingdom and Eire

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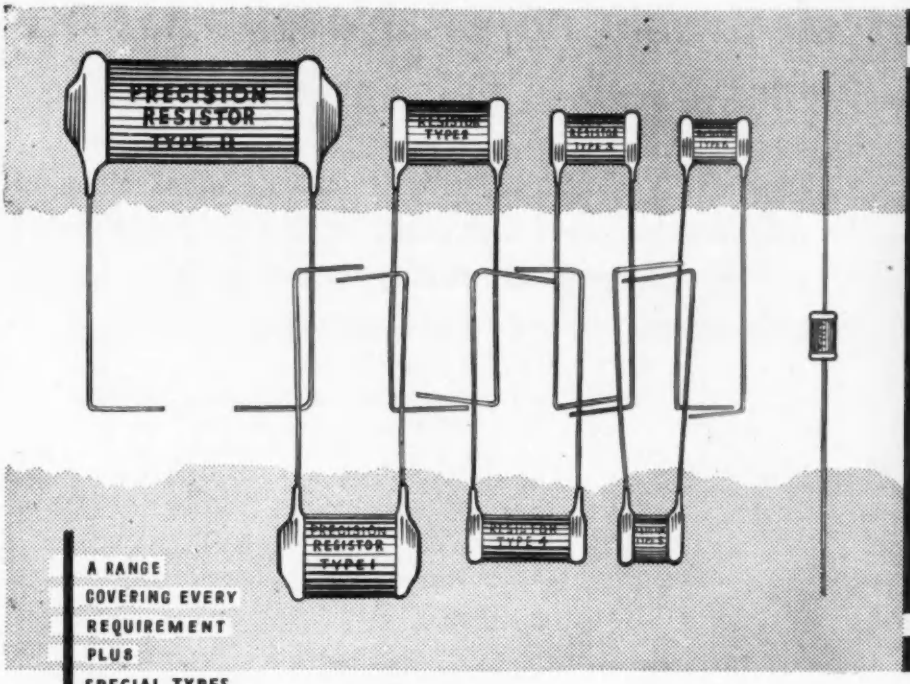

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PLUS
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TO YOUR
PARTICULAR
NEED

Accuracy up to ±0.1 per cent or ±0.01 Ω whichever is the greater.

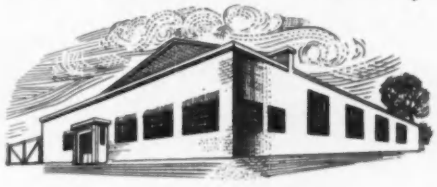
- *All values available in the range 0.1 Ω to 3 Megohms with a temperature coefficient of 0.002 per cent °C.*

Standard ratings: ⅛W, ¼W, ½W, ¾W 1W, 2W. and 3W.

Low-Inductance windings available in most sizes.

The Rivlin range of eight precision wirewound resistors, from ⅛w to 3w, now covers most normal requirements. Additionally special types, higher ratings and American equivalents can be supplied to order. Skilled design and the highest standards of craftsmanship in production combine to give Rivlin their firm reputation for making precision resistors that are without equal. Add to these the fact that the name Rivlin is a byword for personal service and quick delivery, and you have the reason for which Rivlin describe themselves and their products as 'the OHM of Reliability'.

RIVLIN—
The 'OHM' of Reliability



RIVLIN PRECISION WIREWOUND RESISTORS

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ELECTRONIC ENGINEERS

EE 3028 *for further details*

New *low cost* electronic adjustable speed drive has general purpose industrial applications

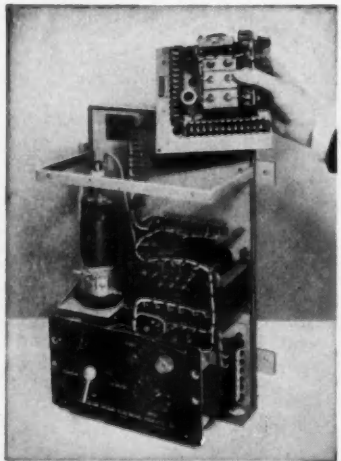
Long experience and extensive development bring to machine designers and users in this new equipment all the features of electronic drives in a simple compact easy-to-use form at an economic price.

IN RATINGS UP TO ONE H.P. this new series offers up to 20 : 1 speed range, flat load / speed characteristic (within 2% from no load to full load), current limit, forward and reverse operation, dynamic braking—all at the lowest cost yet.

EASY TO INSTAL, just connect the a.c. supply and the motor—low in installation as well as first cost.

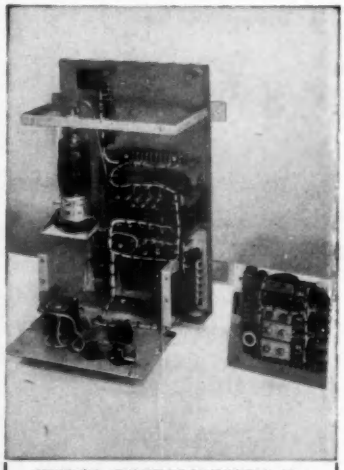
SMALL IN SIZE, (19¼" x 12¼" x 6¼") and light in weight, the units open new possibilities for built-in machine drives, using versions available without the enclosing cover for such requirements.

This new self-contained, high performance adjustable speed drive is the latest addition to Britain's widest range of electronic equipment, which includes the most comprehensive selection of specialised drives for every type of application — multi-motor speed matching, very high accuracy speed regulation, tension control, reeling and coiling and many others where controlled adjustable speed is needed.



UNIT CONSTRUCTION for economy and ease of maintenance. One control unit, easily removable with a screwdriver, is used in all ratings.

FINGERTIP SPEED ADJUSTMENT accurately sets speed despite load changes. Compact control panel provides for starting and reversing as well as speed setting.



COMPACT—YET FULLY ACCESSIBLE, the flat back wall mounting design and hinge forward control panel enable all components to be reached without difficulty.

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ELECTRONIC BEP EQUIPMENT

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Manufacturers of Britain's widest range of industrial electronic equipment

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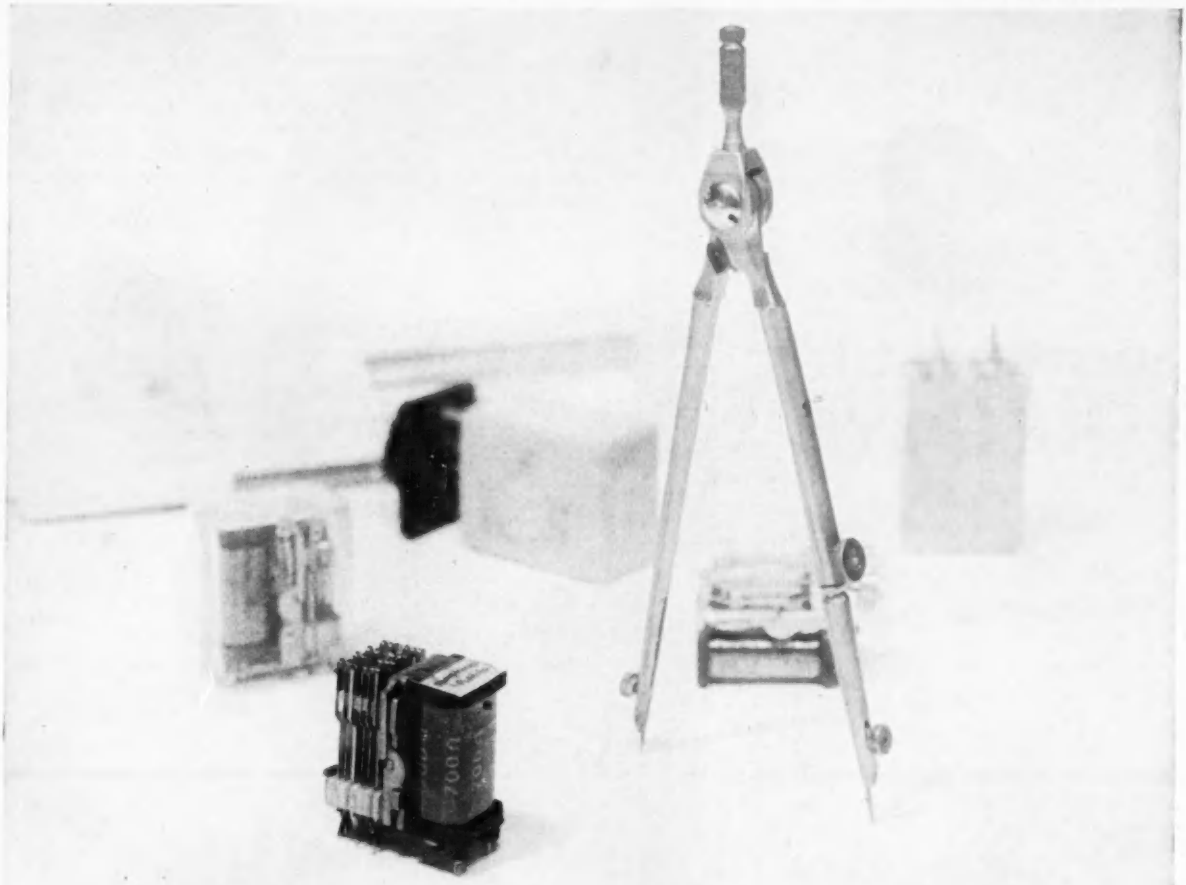

RELAY DESIGN PERFECTED

Result of 3 year research plan at **Plessey**

A top Plessey research team has been engaged on a special project—producing a superior, fault-free range of small D.C. relays—which is of special interest to all those concerned with equipment design.

Thorough study of modern relay requirements plus the use of new materials and up to date manufacturing techniques have helped to evolve and perfect a series of relays of an unusually advanced design.

They offer a great variety of contact arrangements and ratings, and rigorous tests have shown them to be robust and consistently reliable. The Services type approved series of Plessey relays can be supplied either hermetically sealed or unsealed and has a very wide temperature range.

For full information about this new range of relays write for Publication Nos. 103 and 110.

COMPONENTS GROUP

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Overseas Sales Organisation: Plessey International Limited, Ilford, Essex

EE 3030 *for further details*

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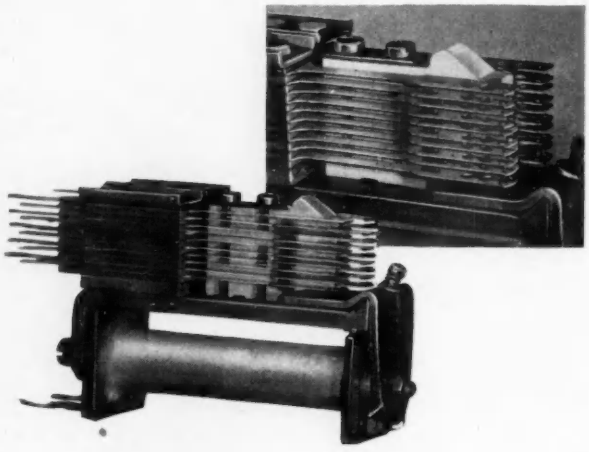
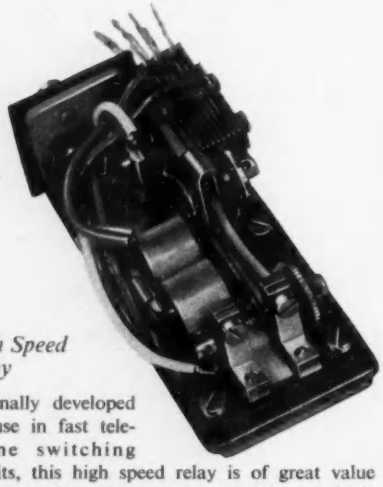
These relays are
available for early delivery
your enquiries are welcomed

Comb Relay

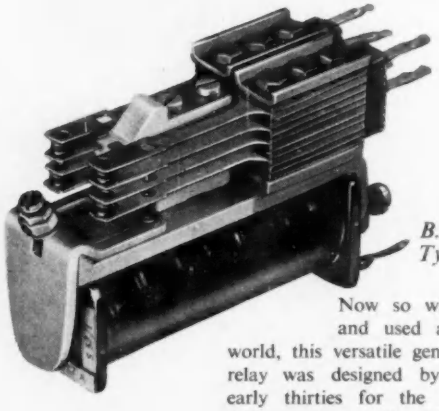
This is our latest development in relays and will give 100 million operations without the need for readjustment. Long life and reliability have led to its adoption by the British Post Office for use where continuous pulsing is required. A wide range of contact combinations is available with a maximum of 10 make or 10 break actions. It is suitable for switching light currents at 250 v.





High Speed Relay

Originally developed for use in fast telephone switching circuits, this high speed relay is of great value in automation systems. It can effect a single changeover action in as little as 1.5 milliseconds. A high speed relay is also available with two changeover actions.



B.P.O. 3000 Type

Now so widely known and used all over the world, this versatile general purpose relay was designed by us in the early thirties for the British Post Office. Many millions are now in use in both telephone and industrial applications. It is available in an extremely wide range of coil resistances and spring set combinations for practically all normal voltages and frequencies.

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It measures Inductance from 1μH to 100H, Capacitance from 1μμF to 100μF and Resistance from 0.1Ω to 10 MΩ on a single direct-reading LCR dial. Among the many Marconi instruments specially designed for component testing, the TF 868A is understandably one of the most sought-after, and if you would like further details please write for Leaflet J136.

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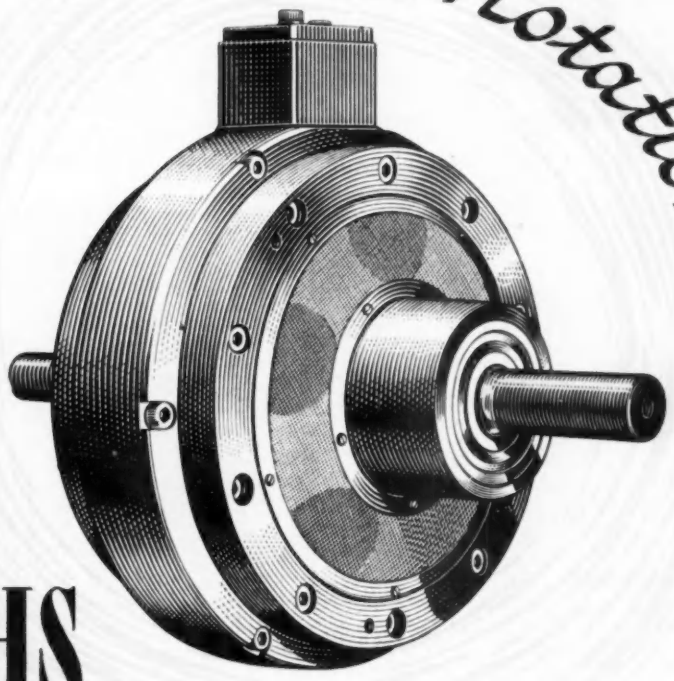
Revolution in Rotation



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which combines:—**the resilience of the hydraulic coupling and the positiveness of the frictional coupling.** It is revolutionary in that driving and driven elements are coupled by magnetically-activated particles. It has these advantages:—

Accurate torque control
No mechanical engagement and thus negligible wear
Accurate torque limiting slip on overload
Acts as brake or coupling in **either** direction
Perfectly smooth operation
No slip rings—excitation coil is stationary
Remote control at any distance
Dynamic and static coefficients of friction equal

The range comprises eight standard units with torque capacities from ½ to 200 lb/ft.

SMITHS Magnetic Particle COUPLING is unique, its potentialities enormous. Let us advise you, therefore, how best to use it in your particular field.

SMITHS **S. SMITH & SONS (ENGLAND) LTD.**

INDUSTRIAL PRODUCTS DEPARTMENT, WITNEY, OXON.

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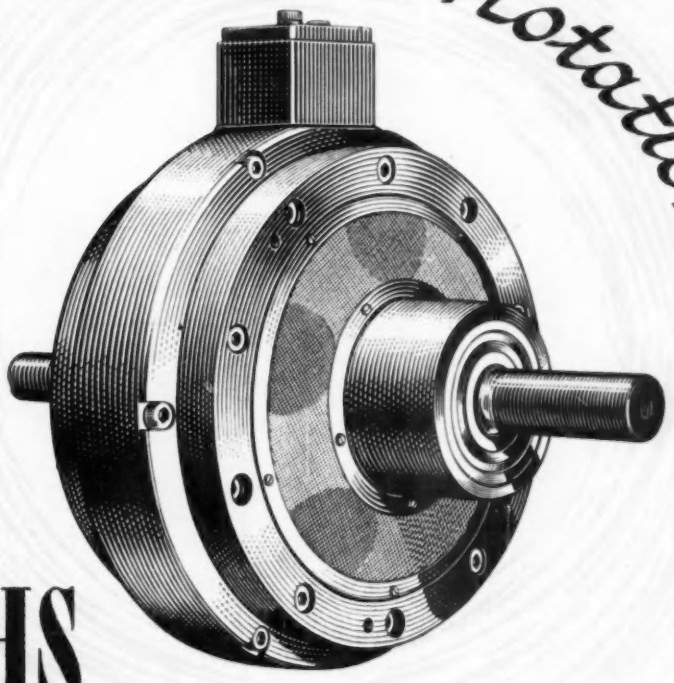

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No slip rings—excitation coil is stationary
Remote control at any distance
Dynamic and static coefficients of friction equal

The range comprises eight standard units with torque capacities from ½ to 200 lb/ft.

SMITHS Magnetic Particle COUPLING is unique, its potentialities enormous. Let us advise you, therefore, how best to use it in your particular field.

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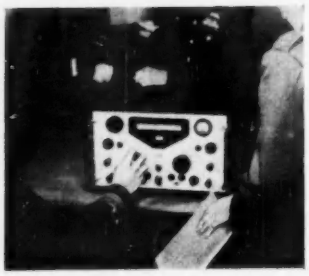


RACAL development —

. see front cover

While others have distributed their energies in diffused and widely-ranging aspects of electronics design, manufacture and contracting,

H.F. AND V.H.F. COMMUNICATIONS

Unquestionably, Racal's greatest achievement in the Communications field is the revolutionary RA.17 H.F. Communications Receiver. In itself, this receiver represents a sensational advance in receiver design, giving a performance of very high quality with quite exceptional ease and accuracy of setting—bandswitching having been completely eliminated over its entire range of 0.5 to 30Mc/s. Indeed, nearly 2,000 have been sold to civil and military authorities all over the world against considerable international competition, on the strength of its intrinsic superiority and versatility. A range of ancillary equipments covers low frequency operation down to 12½kc/s, single and dual diversity F.S.K. for high-speed teletype reception, S.S.B., D.S.B. and I.S.B. reception. A panoramic adapter has also recently been introduced.

Other Racal communications equipment includes the new TRA.55 60-watt S.S.B. Radiotelephone—a compact, transportable, tropicalised equipment ideal for overseas use; wideband matching transformers, co-axial switches, V.H.F. Yagi aerial arrays, speech secrecy equipment and other specialised products.

LITERATURE IS AVAILABLE IN SYNOPSIS OR FULLY-DETAILED FORM

COMMUNICATIONS H.F. AND V.H.F.

RACAL

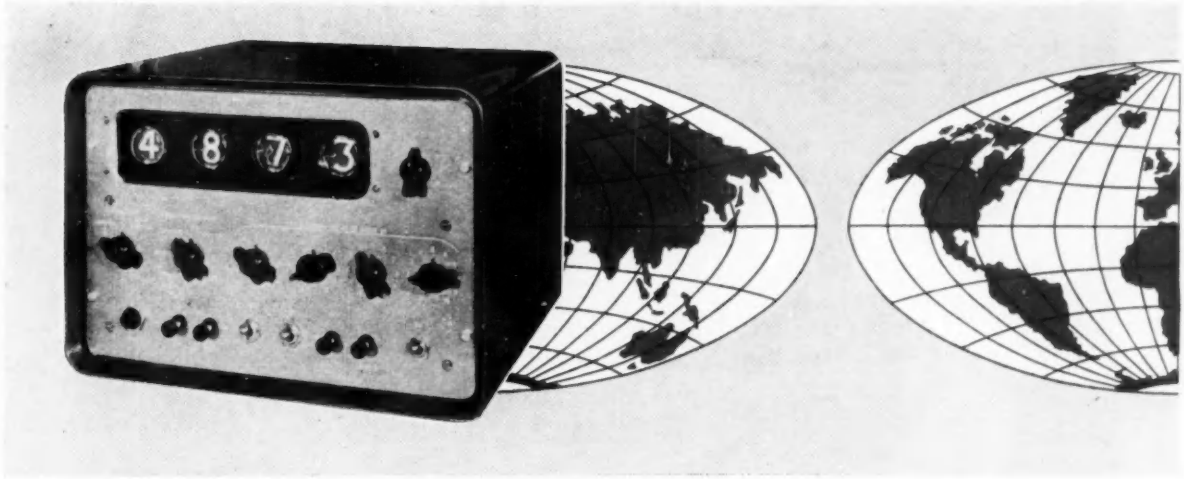
BRACKNELL

North England Agent:
Farnell Instruments Ltd.
Wetherby Industrial Estate,
York Road,
Wetherby, Yorks.
Telephone: Wetherby 2544

— sells British ELECTRONICS

Racal have specialized. Even within the broad fields of Communications and Instrumentation, they have concentrated upon the exhaustive researching and painstaking development of specialized principles and techniques—with notable results and international recognition.

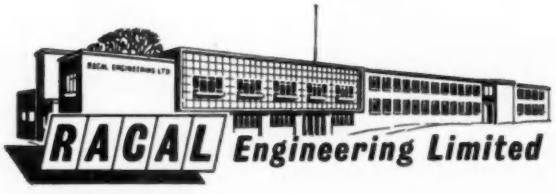
Today, less than ten years since their foundation, they rank among the few virile and highly individual British companies whose manufacturing genius is matched by a world-wide marketing sense—to the benefit of our technological prestige no less than to our trade balances in both hard and soft currency areas.



DIGITAL INSTRUMENTATION

From the beginning, Racal have appreciated the many advantages which digital processing of frequency measurement, pulse counting, timing and data handling operations offers to the designer and operator of laboratory, control and production equipment. To these advantages, which combine to give very great accuracy in most easily assimilable form, Racal have added the considerable production economy which their now-famous "plug-in unit" principle of manufacture affords.

The wide range of Racal standard digital counting equipments represents the accumulation of unique experience in the applications of digital techniques, and covers every requirement so far encountered, from shock wave measurement, crystal calibration and scintillation counting to simple tachometry and chronometry. The new fully-transistorized SA.501 computing counter controller illustrated features in-line and read-out, with facilities for remote printing and control processes.



RACAL *Engineering Limited*

BERKSHIRE

Telephone: Bracknell 941
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3A St. Vincent Street, Edinburgh,
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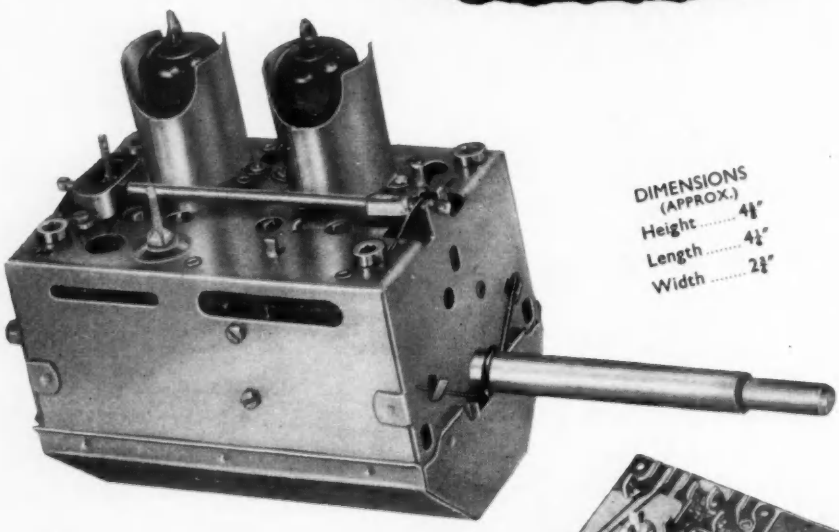
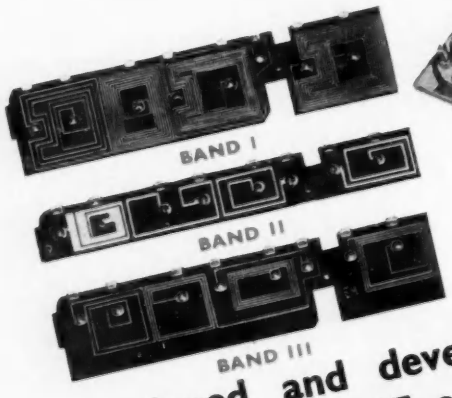
DIGITAL INSTRUMENTATION

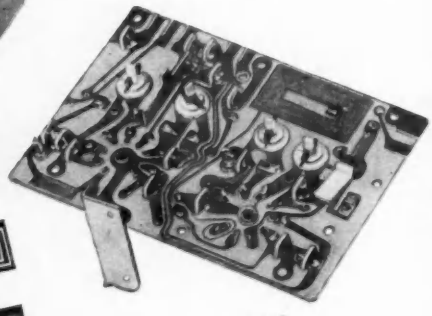
*THE SOLUTION to an entirely new conception of TV Tuner design!



DIMENSIONS (APPROX.)
Height ..... 4¼"
Length ..... 4¼"
Width ..... 2⅜"



BAND I
BAND II
BAND III



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Designed and developed specifically for both HOME and EXPORT use.

14 POSITION · 17 CHANNEL

"Cyldon"

THE TURRET TELETUNER

REGD. TRADE MARK WORLD PATENTS PENDING

OUR PRINTED CIRCUIT STORY

Chapter VI

We now come to the conclusion of our story, and having published this information wish to thank the many trade friends who have expressed their appreciation and are now satisfactorily using this component.

It is generally agreed that the Printed-Circuit Turret Teletuner is the most flexible and economic method of providing complete or adequate tuning facility for both Home and Export requirements. The only disbelievers of this fact are fortunately our own laboratory engineers who are already investigating even better methods, both on V.H.F. and U.H.F.

This, however, is in line with our policy of specialisation in this particular field of the industry, and receiver designers may safely leave these problems with us should they desire. Please rest assured of our constant endeavour to play our part in keeping our clients to the forefront on quality, performance and price.

The End

SYDNEY S. BIRD & SONS Ltd. POOLE DORSET

Address for enquiries and sales correspondence:
London Sales & Technical Liaison Office: 3 Palace Mansions, Palace Gardens, Enfield, Middx.
Telephone: Enfield 8571-3. *Telegrams: "Capacity-Enfield."*

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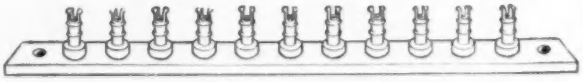
precision built

TERMINAL BOARDS



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We are the only Company in
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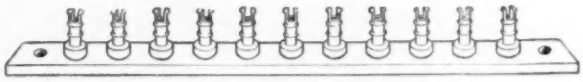

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We are the only Company in
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competitive prices available.
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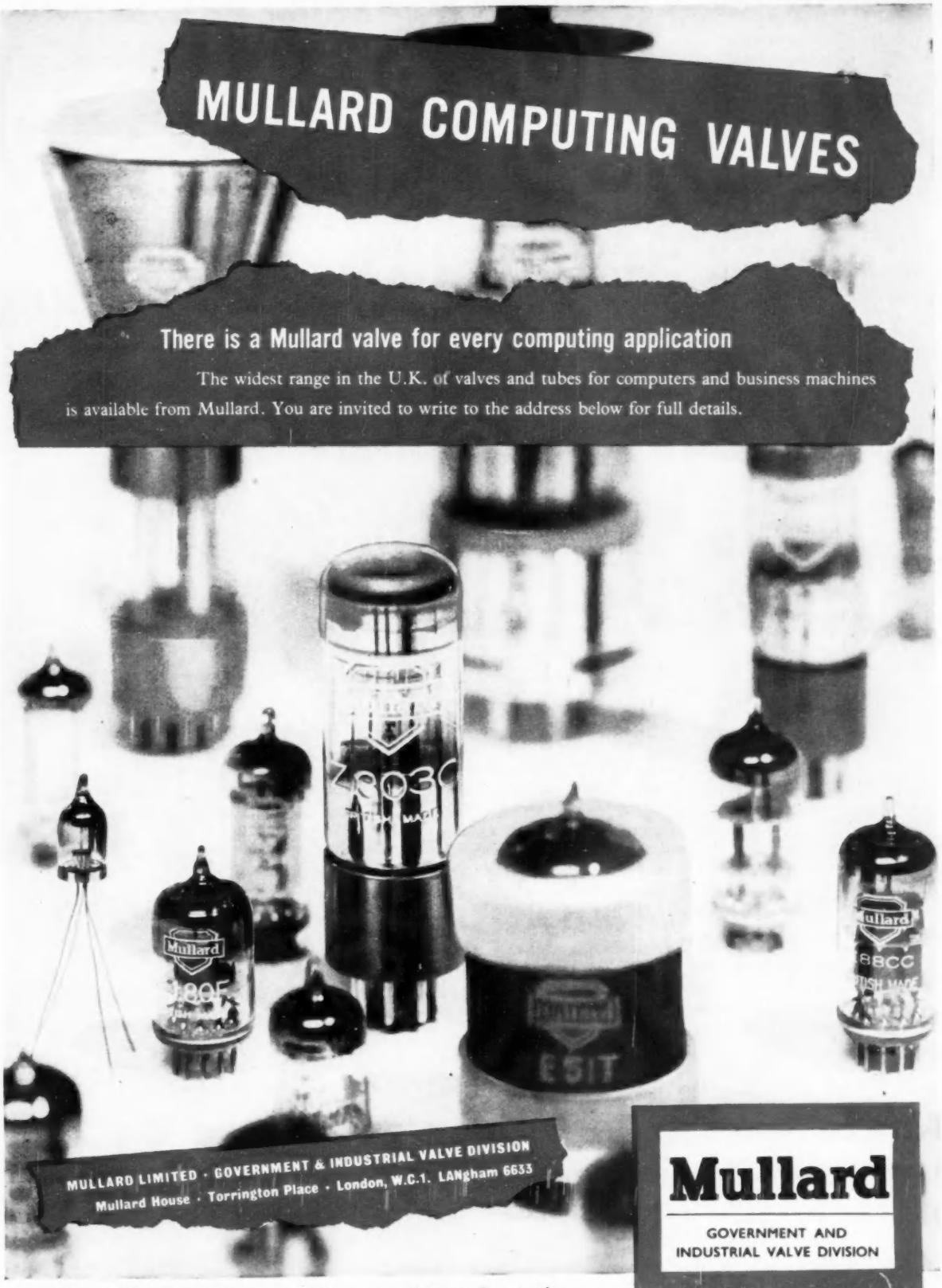
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COMBINATION INSULATION

by Delanco REGD.

IT'S RIGHT HERE

To meet the growing demand for a better slot insulation, the **DELANCO** organization have developed a composite material combining the highest mechanical and electrical properties with extreme flexibility. This has been achieved by welding, with a special heat resisting bonding agent, Tri-acetate or Polyester film to the highest grade of pressboard. The resultant product is a very flexible material combining high electrical and mechanical strength in one material, making it ideally suitable for slot liner insulation. Combined thickness ranges from .005" to .020" and can be supplied in reels cut to any specified width. It is capable of operation at class E Temperatures (120° C.)

DELANCO Tri-acetate combination material, though mainly designed for slot insulation, can also be used for other electro-technical purposes, where a combination of good insulation and only slight layer thickness is demanded. The **DELANCO** technical department has produced a folder giving full technical data, and this with sample, will gladly be sent you on request.

Anglo-American Vulcanized Fibre Co. Ltd

CAYTON WORKS BATH STREET LONDON E.C.1. CLE 3271 Grams: 'PROMPSERV' AVE, LONDON

DELANCO WORKS · LEONARD STREET · LONDON E.C.2

VULCANIZED FIBRE · LAMINATED BAKELITE
PRESSBOARD · PRESSPAHN · CLOTHS, TAPES AND SLEEVINGS

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LEATHEROID · MICA · COMPOSITE INSULATIONS
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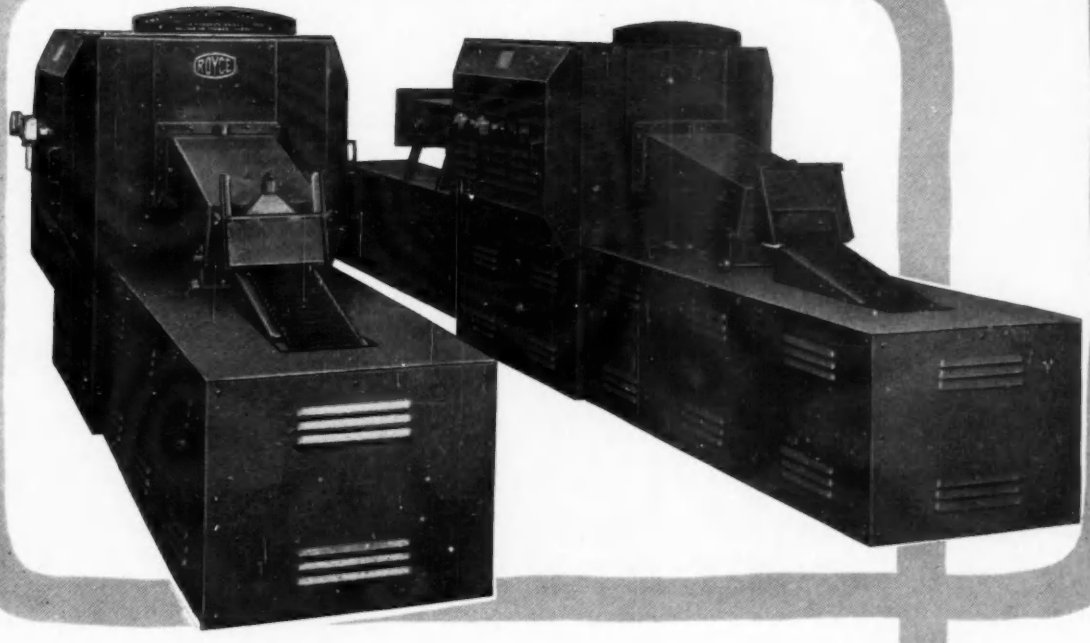
Controlled Atmosphere Furnaces for special heat treatment requirements

For over 30 years Royce have specialised in controlled atmosphere furnaces—continuous or batch type—using hydrogen, cracked ammonia, nitrogen, argon, endothermic or exothermic gas. Royce service includes advice on and the supply of atmosphere generating plant.



An example of Royce designs are the hump-back conveyor furnaces above. Perfect gas balance under continuous operation is obtained with atmosphere consumption reduced to a third of a straight conveyor furnace. No burning off at doors is required.

For further details write for Leaflet

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NRP/RF322

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Designers and manufacturers of furnaces, ovens & kilns for all industries

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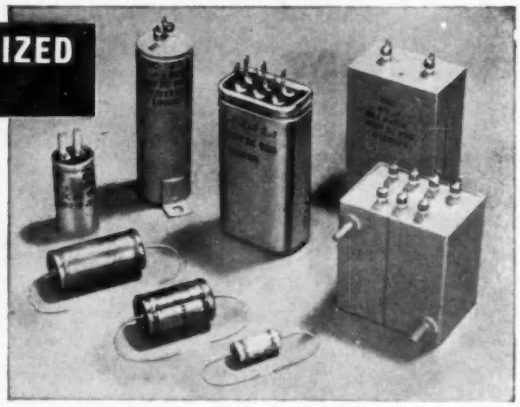
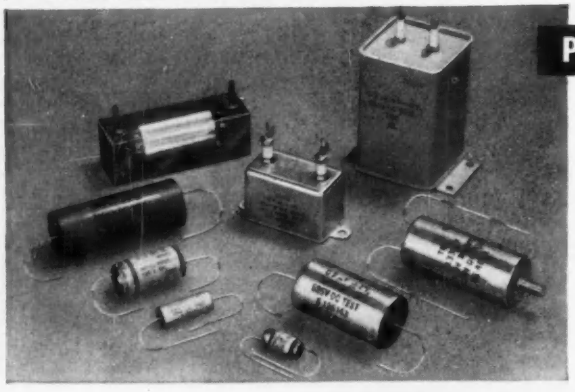
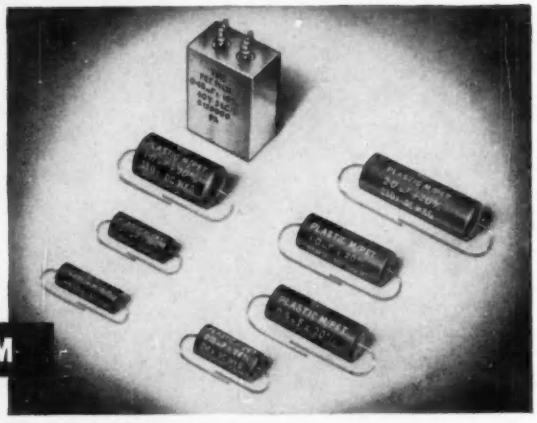
METALLIZED PAPER

PRECISION PAPER





POLYSTYRENE



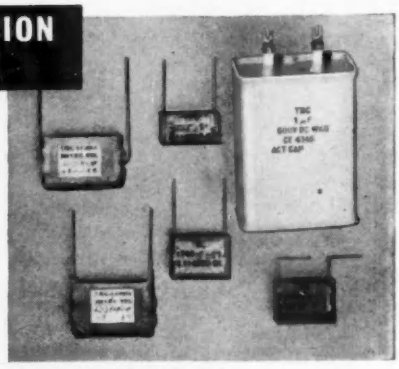
METALLIZED FILM

TMC

CAPACITORS

DESIGNED TO COMMUNICATIONS STANDARDS

PRECISION MICA



...offer the engineer

RELIABILITY +

In addition to standard ranges of metallized paper, precision paper and silvered mica capacitors, we also have many designs and ratings suitable for abnormal conditions and unusual locations.

✳ **TMC POLYSTYRENE CAPACITORS**

have an insulation 50 times greater than Mica with comparable stability, plus an attractive price advantage.

✳ **TMC METALLIZED MELINEX CAPACITORS**

are a high grade successor to Metallized Paper, with smaller dimensions and an operational temperature range up to 150°C.

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VARIABLE TRANSFORMER

6 Standard Models 250 VA - 2.5 kVA

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THE BRITISH ELECTRIC RESISTANCE CO LTD
in association with
THE BRITISH POWER TRANSFORMER CO LTD
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5A

EVEN IF THEY HAVE TO BE SPECIALLY MADE

We've always said that Unbrako screws cost less than trouble.

But it happens that once in a while a customer needs a screw that cannot be found even in the vast Unbrako range.

So we make them to the customer's own specification, or design specially for him.

And even when we have to make specially, Unbrako still costs less than trouble.

So, rest assured, standard or not, you can always safely specify Unbrako screws and make sure of getting the finest fasteners that are made anywhere in the world. Details of sizes and threads will gladly be sent on request.

UNBRAKO SOCKET SCREW COMPANY LIMITED · COVENTRY

FOR HARD VALVE MODULATOR CIRCUITS

the E.E.V. C1133 has the same specifications as the 4PR60A. It also meets all the requirements of military and commercial specifications with the additional advantage of smaller bulk. Conditioning at 30 kV and rigorous testing ensure thoroughly reliable operation right up to the maximum peak anode voltage and current ratings of 25 kV, 18 A.

'ENGLISH ELECTRIC'

Typical Operation

D.C. Anode Voltage	*20 kV*
Peak Anode Voltage	*25 kV*
Screen Voltage	*1 25 kV*
Grid Voltage	*600 V*
Pulse Anode Current	*16 A*
Peak Anode Current	*18 A*
Pulse Output Power	*300 kW*
Duty Cycle	*0.001*
Pulse Length	*2 μsecs*

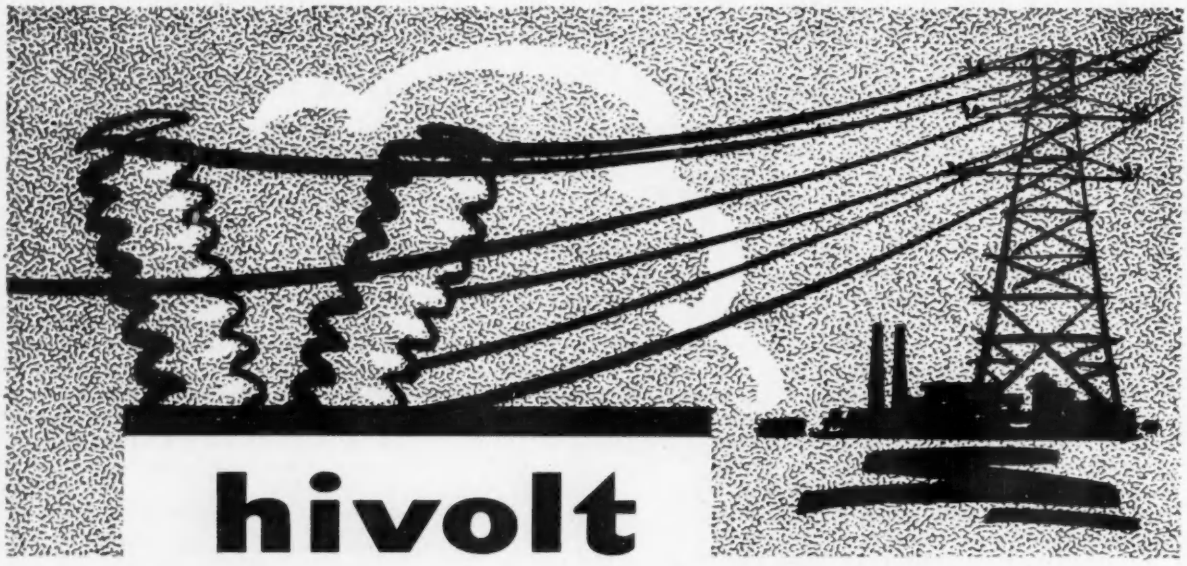
A lower rated version, the C1111, *is also available.*

Abridged Data

Type	Plug-in replacement for	Overall Length Max.	Overall Diameter Max.	Net Weight	Heater Voltage	Anode Voltage Max. D.C.	Peak Anode Voltage Max.	Peak Anode Current Max.	Screen Voltage Max.	Anode Dissipation Max.
C1133 (CV2416)	4PR60A 715C CV427 CV2752	152 mm	65 mm	9 oz.	26	20 kV	25 kV	18 A	1500 V	60 W
C1111	715C CV427 CV398	152 mm	65 mm	9 oz.	26	17.5 kV	20 kV	15 A	1500 V	60 W

ENGLISH ELECTRIC VALVE CO. LTD. *Chelmsford, England*
Telephone: Chelmsford 3491

AP/112

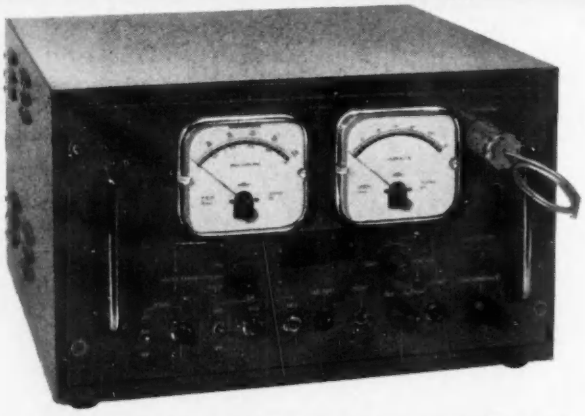


hivolt

high-voltage research and development

Hivolt are specialists. They specialise in the development of instruments and equipment for high-voltage users. Their clients over the past 10 years include all the major establishments in the world where high voltages are required.

For more detailed information of standard and special products please write to Hivolt Limited, 93, Princedale Road, London, W.11.



3 - 30 KV Stabilized Power Supply and Breakdown Tester

With reversible polarity and capable of giving 1 mA throughout the whole range, this versatile Hivolt instrument can be used both as a power supply and as a breakdown tester. Stabilized against changes of load and mains.

£145 0. 0. ex works

The EDDYSTONE 730/4

The "730/4" receiver combines a first-class performance with robustness of construction. It is used extensively by the British Government and in professional communications systems throughout the World.

Your particular interest is directed to the following features which are important in a receiver designed for professional communications:—

- ★ **Excellent all-round performance.**
- ★ **Ease of tuning; minimum of operator fatigue.**
- ★ **Excellent reliability under all conditions.**
- ★ **Peak performance maintained in arduous service with minimum attention.**
- ★ **CV valves used throughout.**
- ★ **Suitable for 24-hours-a-day operation.**
- ★ **Robustly constructed, the "730/4" stands up well to hard usage in all climates.**
- ★ **Easy to service—spares readily available.**

PLEASE WRITE FOR COMPLETE SPECIFICATION

RADIO PRODUCTS EDDYSTONE TRADE MARK

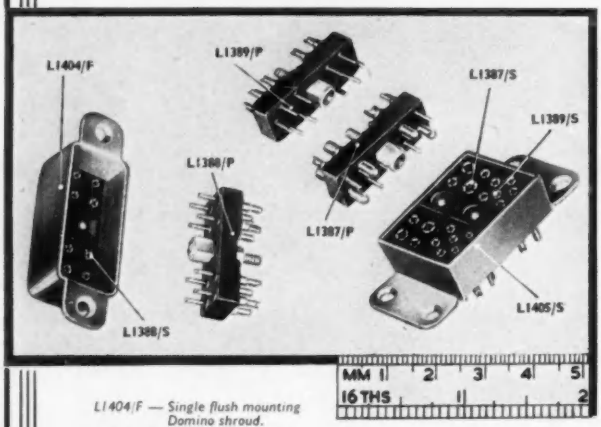
Manufactured by STRATTON & CO. LTD. BIRMINGHAM 31

Distributors in all parts of the World

"BELLING-LEE"

DOMINO

MINIATURE UNITORS



L1404/F — Single flush mounting Domino shroud.
L1388/P & S — 8 way Domino plug and socket.
L1405/S — Double surface mounting Domino shroud.
L1387/P & S — 4 x 4 Domino plug and socket.
L1389/P & S — 12 way Domino plug and socket.

provide maximum versatility

One of the outstanding features of our new Domino Miniature Unitors is their great versatility. The accompanying table shows the wide variety of arrangements possible when using combinations of the three pairs of plugs and sockets now available, in conjunction with the new metal shrouds. These accommodate one, two or three Unitors and can be supplied for flush or surface mounting.

Moisture- and tracking-resistant nylon-filled phenolic material is used for body mouldings. Pins are of gold-plated* or silver-plated brass. Sockets of high grade beryllium copper, slotted to ensure good contact with pin.

Each assembly has a shaped centre pin which polarizes the plug on engagement, and the back of this pin carries an 8BA stud for mounting the Unitor on chassis or panel.

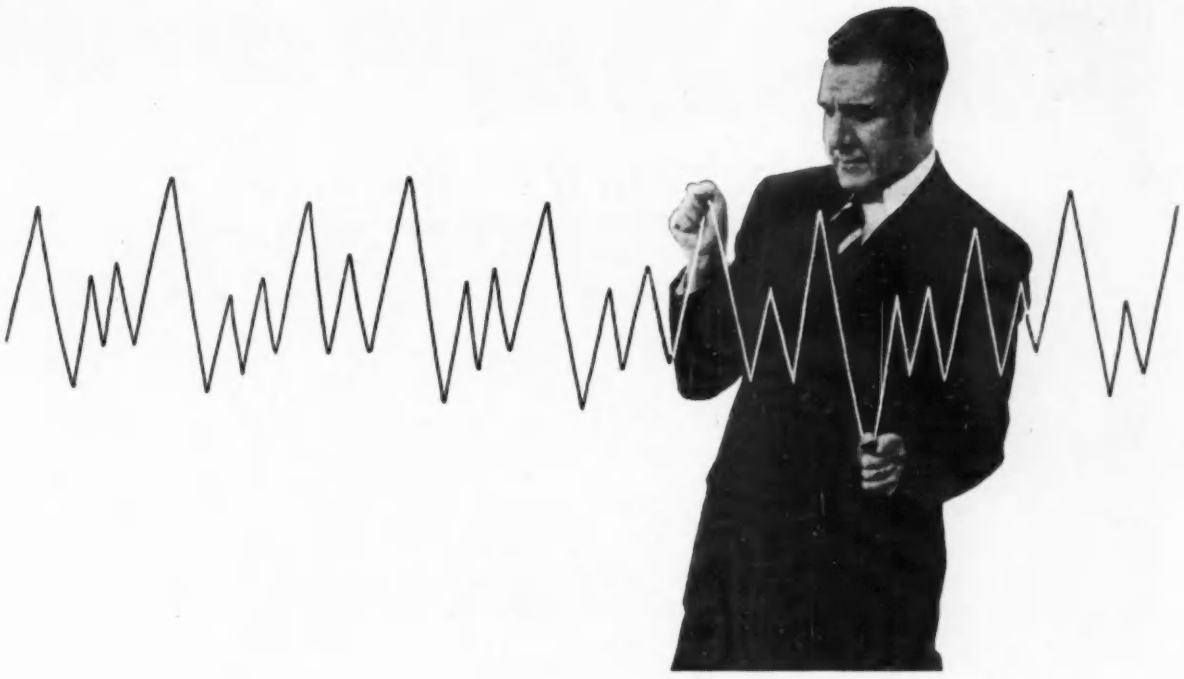
**As distinct from gold flash.*

UNITORS	LARGE PINS	SMALL PINS	POSSIBLE ARRANGEMENTS
L1388	—	8	2
L1389	—	12	2
2 x L1388	—	16	18
L1388 + L1389	—	20	24
2 x L1389	—	24	18
2 x L1388 + L1389	—	28	96
2 x L1389 + L1388	—	32	96
3 x L1389	—	36	48
L1387	4	4	2
L1387 + L1388	4	12	24
L1387 + L1389	4	16	24
L1387 + 2 x L1388	4	20	96
L1387 + L1388 + L1389	4	24	144
L1387 + 2 x L1389	4	28	96
2 x L1387	8	8	18
2 x L1387 + L1388	8	16	96
2 x L1387 + L1389	8	20	96
3 x L1387	12	12	48

Most "Belling-Lee" products are covered by patents or registered designs or applications therefor

BELLING & LEE LTD
GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND
Telephone: Enfield 3322 · Telegrams: Radiobel, Enfield

EE 3049 *for further details*



Why struggle with Mains Voltage Fluctuation?

If you have any problem involving a.c. voltage regulation, the solution is to call in 'Advance' — the C.V.T. specialists.

Investigation of your problem may prove that a standard type Constant Voltage Transformer will meet the case; or maybe, a special design is called for. In either event, the wealth of experience gained by 'Advance' over many years in probing every aspect of mains stabilization provides the surest, quickest, and certainly the most economical, solution to your difficulties.

let *Advance* give you a hand

Technical Details available in Leaflet M54

C V T
CONSTANT VOLTAGE TRANSFORMERS

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FORTIPHONE
for MINIATURIZATION

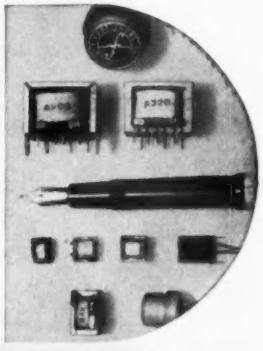
EARPHONES and ACCESSORIES

Thanks to greatly increased production resulting from improved techniques and automation, Fortiphone can offer acoustic units of consistent quality at extremely attractive prices with prompt delivery.
The Fortiphone range includes:

Standard
Wide Frequency Range
High Power (100mW for lapel loud-speaker use) units in the impedance range of 15/2000 ohms
SUB-MINIATURE TYPES (0.62″ diameter)
ACCESSORIES include, cables, connectors, ear-loops, earmoulds, headbands, jack-plugs and sockets.

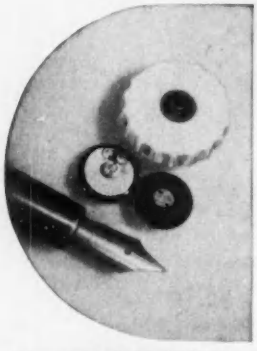
NOTE: *Set makers are invited to apply for quotations for complete "personal listening" kits for miniature radio receivers.*

APPROVED TRANSFORMER RANGE



Granted Advance Quality Approval (Open Types), Advance Limited Approval (Encapsulated Types) to RCS214, the Fortiphone range includes screened, encapsulated, and open types with or without printed circuit terminations and suitable for transistor circuits, microphone matching and many other applications. Push-pull types suitable for 4.5V, 6V, 9V and 12V transistor amplifiers are available.
Miniature bobbins for transformers and transductors are available and complete assemblies can be produced to customers' specifications.

NOTE: *For further details see the Fortiphone Transformer Handbook.*

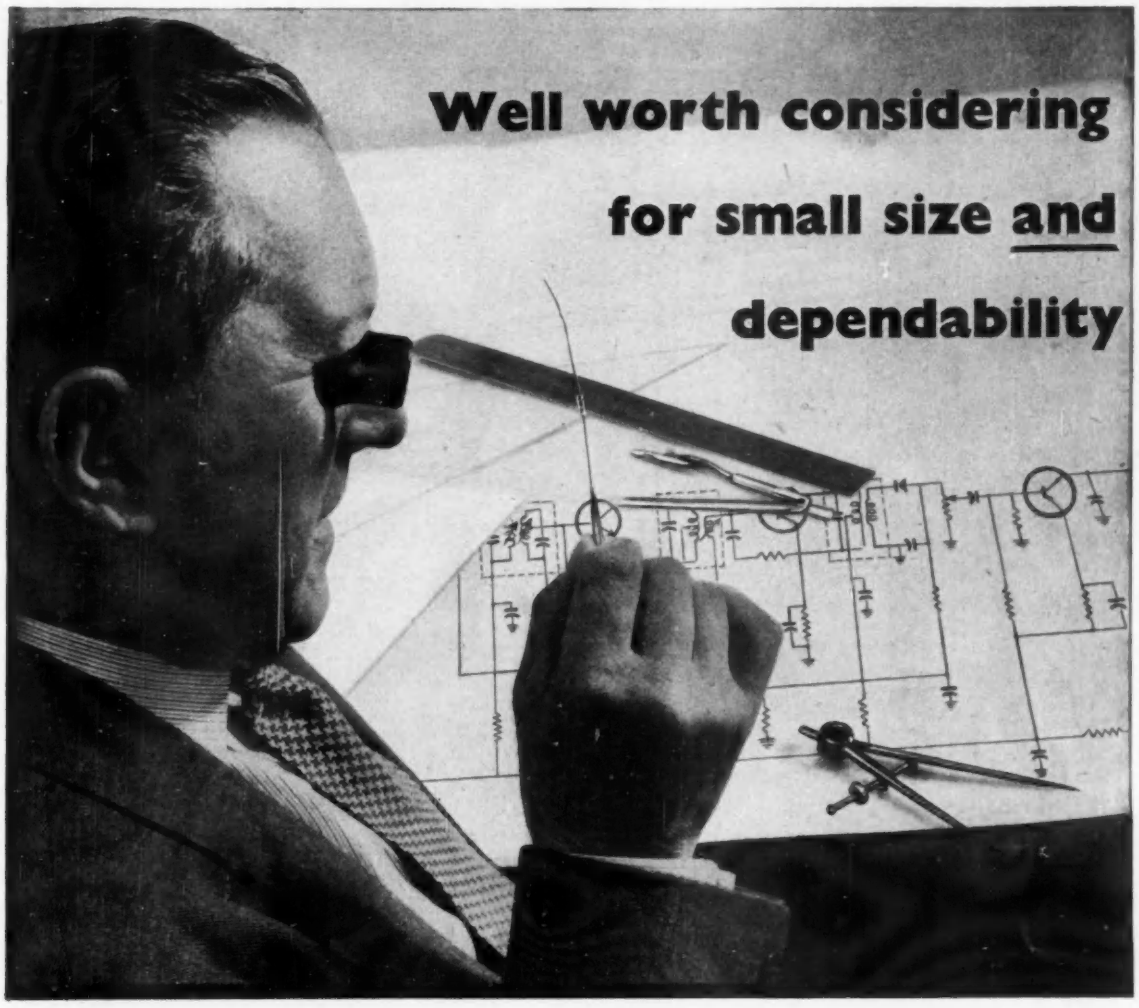


SUBMINIATURE CONTROLS and SWITCHES

The small potentiometer shown in the illustration is typical of a component specially designed for sub-miniature circuit assemblies. This potentiometer, type VC.26A is probably the smallest unit of its kind in the world, and has an overall depth of 0.095″ exclusive of fixing stud and terminations, and a knob overall diameter of 0.45″. A switch potentiometer version is under development. The larger unit shown is available as a switch potentiometer or a multi-position switch.
Further details of the above and many other miniature controls and switches will be supplied on application.

FOR *MINIATURE COMPONENTS AND*
DEVELOPMENT AND PRODUCTION OF MINIATURE
ELECTRONIC EQUIPMENT AND ASSEMBLIES
FINE WIRE WINDINGS
SMALL MOULDED, PRESSED AND MACHINED
PARTS AND SUB-ASSEMBLIES

Consult **FORTIPHONE LIMITED**
92, MIDDLESEX STREET, LONDON, E.1
Telephone: BIShopsgate 0871



The new type BTH Germanium Point Contact Rectifiers—

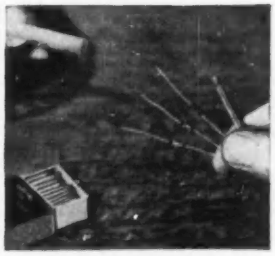
Only ¼ in. long, yet their miniature size is combined with high performance and complete dependability! They offer the following outstanding characteristics:

- **HIGH TEMPERATURE STABILITY**
- **ABILITY TO WITHSTAND TROPICAL CONDITIONS**
- **SMALLER DIMENSIONS**
- **VERY LONG LIFE**

RATINGS: CONTINUOUS OPERATION AT 25°C. (77°F.)

TYPE	PEAK INVERSE VOLTAGE† V	MAX. INPUT CURRENT mA	MAX. RESISTANCE at + 1 volt ohms	MIN. RESISTANCE at − 50 volts kilohms
CV 448*	80	30	333	500
CG41-H	65	30	250	50
CG42-H	100	30	500	1,000
CG44-H	80	30	333	500
CG50-H	100	30	500	200

*Type CV 448 has been granted 'type approval'. †Corresponds to 1·2 mA inverse current.



B T-H

BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON CO·LTD·LINCOLN·ENGLAND

an A.E.I. Company

A 5162

EE 3052 *for further details*

a word about the Dawe window test

Something about the look of my small castings as they lay on the bench caught my eye. I carried them over to the window and there, by critical daylight, I saw that they were cleaner than ever before. I knew then that Dawe ultrasonic cleaning equipment . . .

There are limits beyond which a joke should not be pushed. But the advantages of using Dawe ultrasonic cleaning equipment seem limitless. It offers the quickest and often the only effective method of cleaning small components of intricate shape and removing scale, swarf and grease.

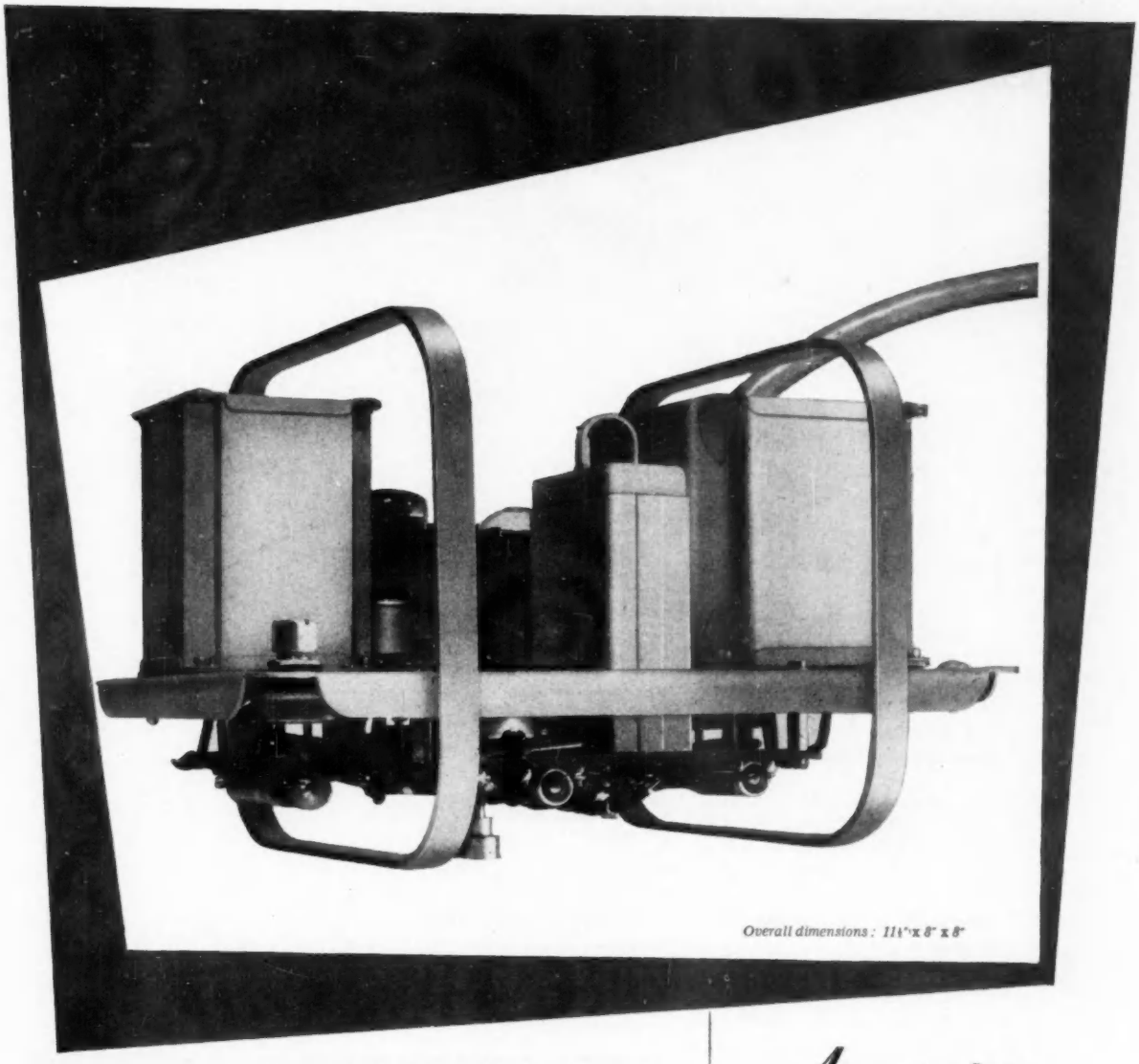
We shall be happy to provide you with some of the finest ultrasonic cleaning equipment in the world. We regret, however, that you must find your own operator to carry out the window test.

(with apologies to the makers of DAZ)

DAWE INSTRUMENTS LTD.
99 UXBRIDGE ROAD, EALING, LONDON, W.5 :: Telephone: EALing 6215

EE 3053 *for further details*

Synchronising AUTOMATICALLY



Overall dimensions: 11½" x 8" x 8"

The new Austinlite Synchronising Unit cuts out the need for complex and time-taking precautions when switching an A.C. generator into an already running A.C. system. The Unit detects voltages, phases and frequencies and, when these are all in step with the system, the generator is paralleled and can be safely switched in.

More than this, with auxiliary apparatus additional generators can be automatically started up, synchronised and connected with the system –and later disconnected–as the power demand fluctuates. The Austinlite Synchroniser can again be combined with other apparatus to form a load sharing device between two paralleled generators.

Simple in design, the Austinlite Synchroniser is self-contained, built on a small chassis suitable for back-of-panel mounting. Installation is an easy matter : little or no maintenance is needed. It can, if required, be used as a conversion unit with existing generating plant.

Let us give you a more detailed description of this unit.

Austinlite

ELECTRICAL EQUIPMENT

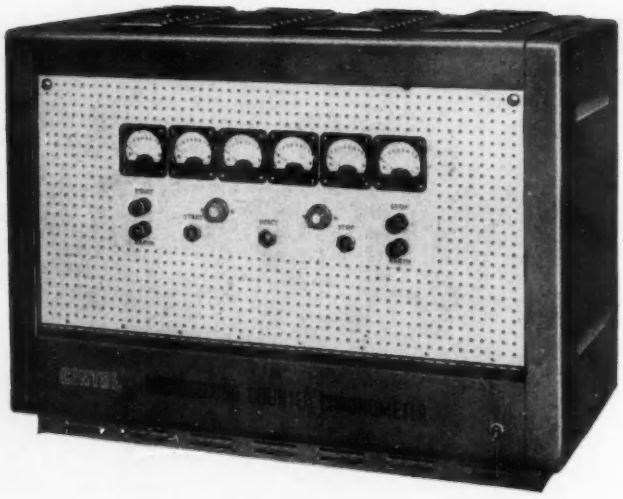
Tailor-made by

STONE-CHANCE LTD.

(makers of Sumo Pumps and Stone-Chance Lighthouses)

CRAWLEY, SUSSEX.

MICROSECOND CHRONOMETER



This equipment is designed to measure small intervals of time to a high order of accuracy and two ranges are provided:

(1) 1 μsec. to 1 sec. in steps of 1 μsec.

(2) 10 μsec. to 10 sec. in steps of 10 μsec.

Accuracy of each range is better than ± 0.005% ± the step interval.

Full details on this and other 'Cintel' Chronometers are available on request.

CINEMA TELEVISION LTD

A COMPANY WITHIN THE RANK ORGANISATION LIMITED

WORSLEY BRIDGE ROAD · LONDON · S.E.26
HITHER GREEN 4600

SALES AND SERVICING AGENTS
Hawnt & Co. Ltd., 59 Moor St., Birmingham, 4
Atkins, Robertson & Whiteford Ltd., Industrial Estate, Thornliebank, Glasgow.
McKellen Automation Ltd., 122 Seymour Grove, Old Trafford, Manchester, 16

EE 3055 *for further details*

ALDRIDGE

do a better job in plastics

If you want a better job done in plastics, Aldridge will do it. Take this new telephone for instance. Thanks in a great measure to the use of plastic mouldings manufactured by Aldridge, here is how it compares with the present conventional type :

- It is approximately 40% lighter
- costs 24% less for materials
- requires only 25% of the labour
- is produced 210% faster
- employs an 8 oz. injection machine instead of a 300 ton moulding press
- doesn't need to be 'de-flashed'
- holes can be punched instead of drilled
- made of tough, high impact polystyrene.

Aldridge do a better job in plastics because they never stop thinking plastics, dreaming plastics and improving their techniques for manufacturing intricate, accurate shapes in plastics. Give them a product in another material—or even one already made in plastics—and it's pretty certain that they'll be able to give you a still better job in plastics. Let them see it in the design stage and they'll show you how it can be simpler, cheaper and better in plastics.

You are invited to get in touch with

ALDRIDGE PLASTICS LTD

An A.E.I. Company

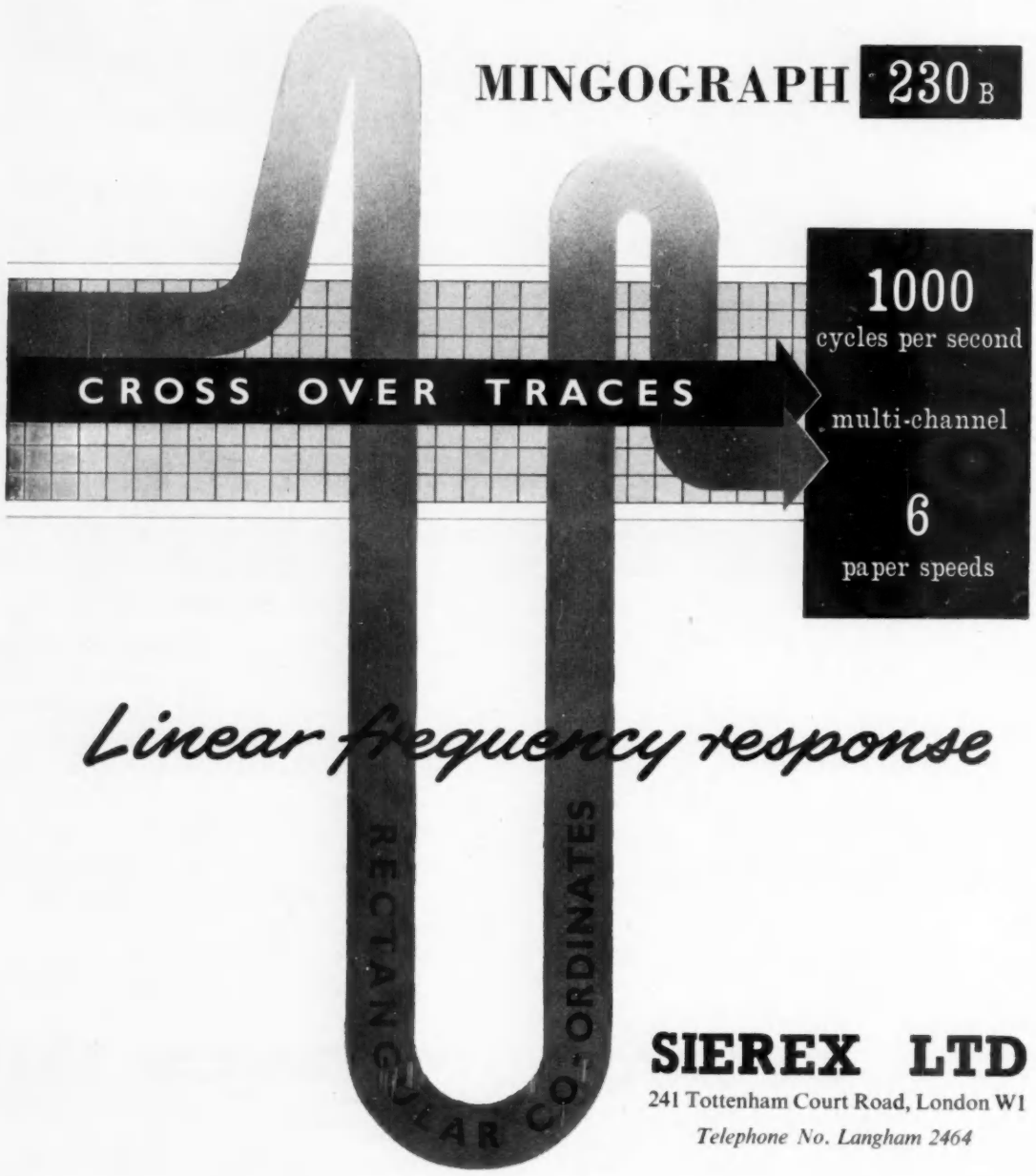
Redhouse Industrial Estate, Aldridge, Staffordshire
Tel: Aldridge 52031 (3 lines)
Sales Office: 155 Charing Cross Road, London, W.C.2
Tel: GERrard 4820 & 8660

CRC A1

EE 3056 *for further details*

A revolution in Oscillographs

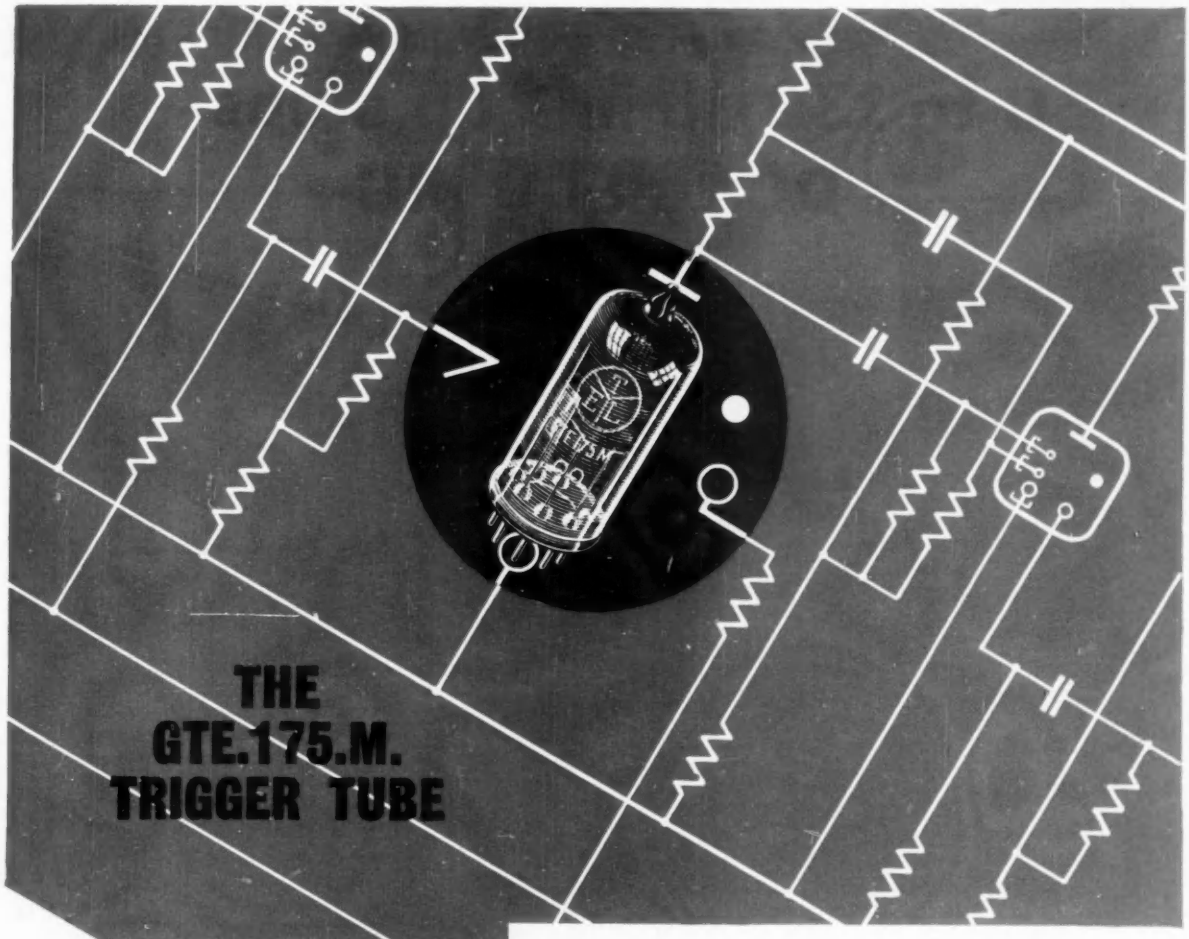
The Mingograph 230B permits direct recordings to be obtained of approximately ten times greater frequency range than has previously been possible. It is an outstanding advance in the field of scientific and industrial measuring instruments.



SIEREX LTD

241 Tottenham Court Road, London W1

Telephone No. Langham 2464



THE GTE.175.M. is a cold-cathode precision trigger tube designed to couple Dekatron stages at up to 500 "carries" per second.

The tube is also used extensively in timing, overload, relay control and similar circuits requiring a constant and drift-free trigger striking voltage. When used as a pulse amplifier or inverter, pulses of 140V amplitude can be obtained at all frequencies below 1 Kc/S. An internal source of ionization enables the tube to be used in complete darkness or bright sunlight without change of characteristics.

The use of a pure metal cathode gives the GTE.175.M. very stable characteristics combined with long life.

For full information write to:- TECHNICAL SERVICES DEPT.

ERICSSON

TUBE DIVISION

BEESTON, NOTTINGHAM

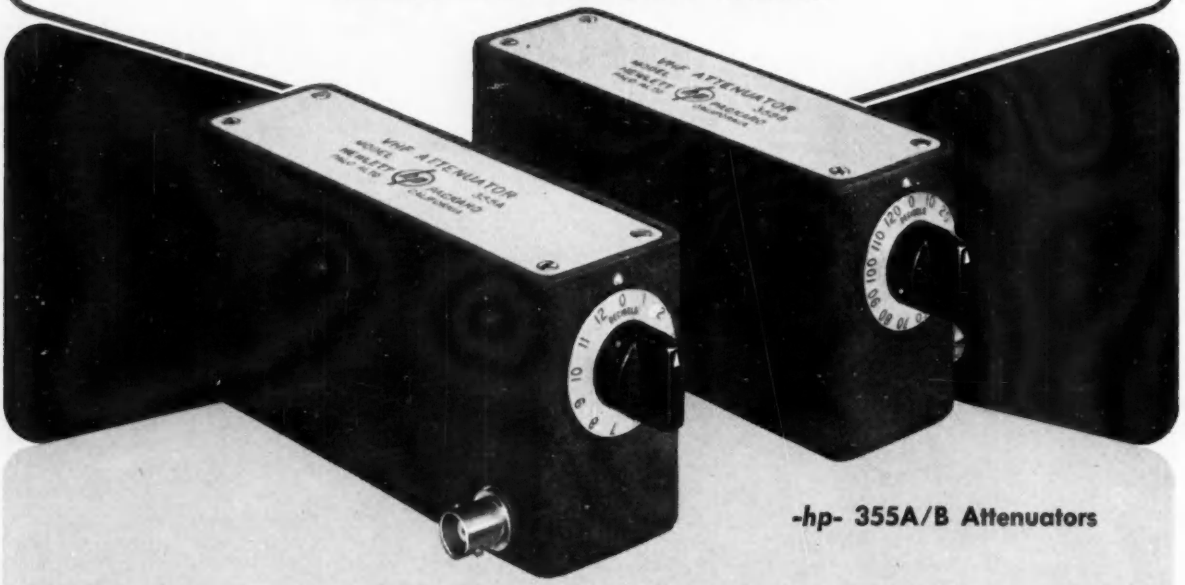
ERICSSON TELEPHONES LTD., HEAD OFFICE, 22 LINCOLN'S INN FIELDS, LONDON, W.C.2

Originators and Sole Manufacturers of the Dekatron Cold-Cathode Tube.

E98A/79A

New design 50 ohm attenuator

0 to 132 db in 1 db steps— DC to 500 MC



-hp- 355A/B Attenuators

¼ db accuracy full range for low attenuation values. Maximum error at full attenuation 2 db. "One-knob" control. Super compact design—size approximately 2½" x 2½" x 6".

These are characteristics of the new, rugged, simple -*hp*- 355A/B attenuators.

-*hp*- 355A provides 0 to 12 db in 1 db steps. -*hp*- 355B provides 0 to 120 db in decade steps. Together, 132 db of attenuation from DC to 500 MC is available, with simplest possible controls, premium accuracy, and no complex setup. A solid-shield 50 ohm connector may be used to interconnect the two attenuators.

These new -*hp*- attenuators have balanced capacities and completely shielded sections. They are enclosed in a sturdy metal case, yet weigh only 1½ pounds.

Ask your -*hp*- representative to show you these practical, minimum-space attenuators this week.

SPECIFICATIONS

Attenuation: -*hp*- 355A, 12 db in 1 db steps. -*hp*- 355B, 120 db in 10 db steps

Frequency Range: DC to 500 MC

Overall Accuracy: -*hp*- 355A, ±0.25 db, DC to 500 MC. -*hp*- 355B, ±1 db, DC to 250 MC, ±2 db, 250 to 500 MC

Nominal Impedance: 50 ohms

Maximum SWR: 1.2 to 250 MC, 1.5 to 500 MC

Max. Insertion Loss: 0 at DC, 0.4 db at 60 MC, 1 db at 250 MC, 1.5 db at 500 MC

Power Dissipation: 0.5 watt average; 350 v peak

Connectors: BNC

Size: 2-3/16" wide, 2-5/8" high, 6" long. Net weight 1½ pounds

Price: -*hp*- 355A, £52 -*hp*- 355B, £52

Delivered in U.K. plus duty if applicable.

Data subject to change without notice.

HEWLETT-PACKARD COMPANY

Represented by:

LIVINGSTON LABORATORIES

RETCAR STREET • LONDON, N. 19, ENGLAND

Tel: Archway 6251

hp offers over 350 quality electronic test instruments

EE 3059 *for further details*

VARLEY

DO ALMOST ANYTHING

. . . and the odds are we are helping you to do it. We are specialists in design for mass production. We also design *and* mass produce to special requirements.

Some of our successes in this field:
Relays and Coils for the Aircraft Industry.
Motors for Hair Dryers.
Coils, Solenoids and Harnesses for the Automobile Industry.
Motors and Solenoids for Washing Machines.
Mechanisms for Electric Razors.
Coils, Solenoids, Relays and Transformers for Computing Automation and other Industries.

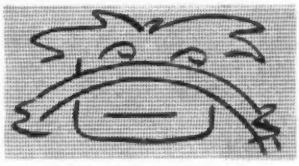
Whether we help you design (which we prefer) or produce components of your own to rigorous schedules; we believe that we can save you money and serve you better . . . Over five decades of experience is at your call . . . Can we use it for YOU.

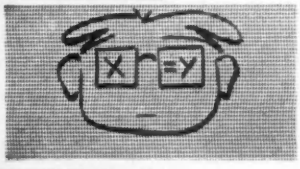
Problem:
Develop a special 14 watt shaded pole motor of 2,400 r.p.m. to run quietly and continuously in high ambient temperatures with a special starting torque.

Solution:
Motor developed by Oliver Pell Control in less than one month. Order Placed. 4 months from order, production of 500 motors a week started. We can do this for **YOU**.

. . . fly

. . . drive





. . . compute

. . . shave

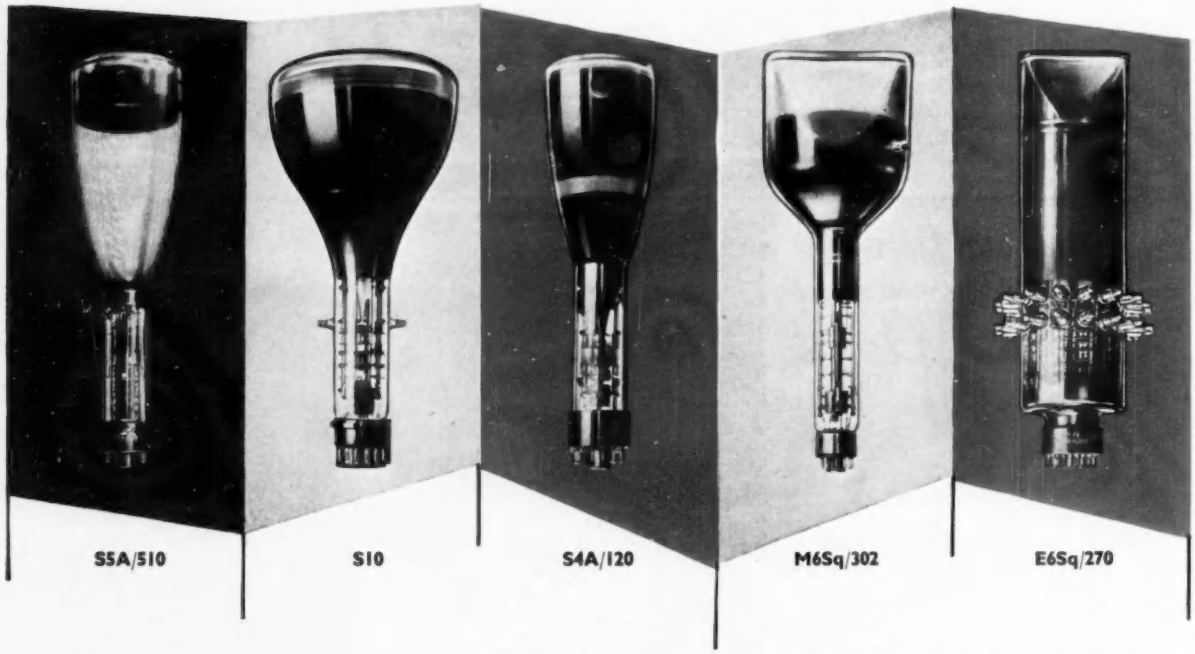
Do almost anything...

Varley
REGD. TRADE MARK

OLIVER PELL CONTROL LIMITED

CAMBRIDGE ROW, WOOLWICH S.E.18, ENGLAND. CABLES: VARLYMAG. WOOLWICH. TELEPHONE: WOOLWICH 1422

OP.EC



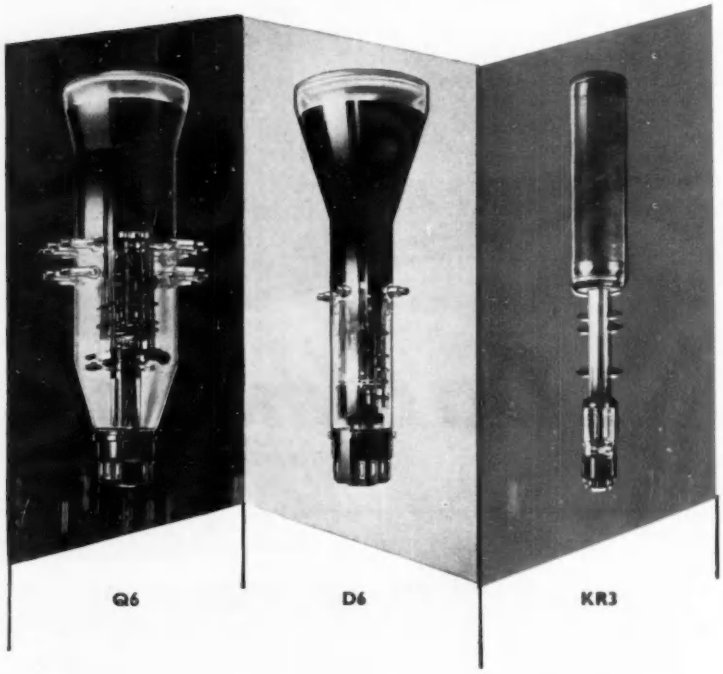
The tubes illustrated are selected from the extensive range of precision instrument cathode ray tubes now available. Catalogue on request.

S5A/510	Very high sensitivity single gun tube.
S10	Large electrostatic demonstration tube.
S4A/120	4" Flat face high sensitivity oscilloscope tube.
M6Sq/302	Square face high resolution magnetic monitor tube.
E6Sq/270	Square face tube with eight independent guns.
Q6	Round face four gun tube with flat screen.
D6	Flat face precision double gun tube.
KR3	3000 Mc/s Travelling Wave Deflector tube.

20th Century range of CATHODE RAY TUBES

20th CENTURY ELECTRONICS LIMITED

20TH CENTURY ELECTRONICS LTD
Centronics Works
King Henry's Drive
New Addington • Surrey
Lodge Hill 2121



EE 3061 *for further details*

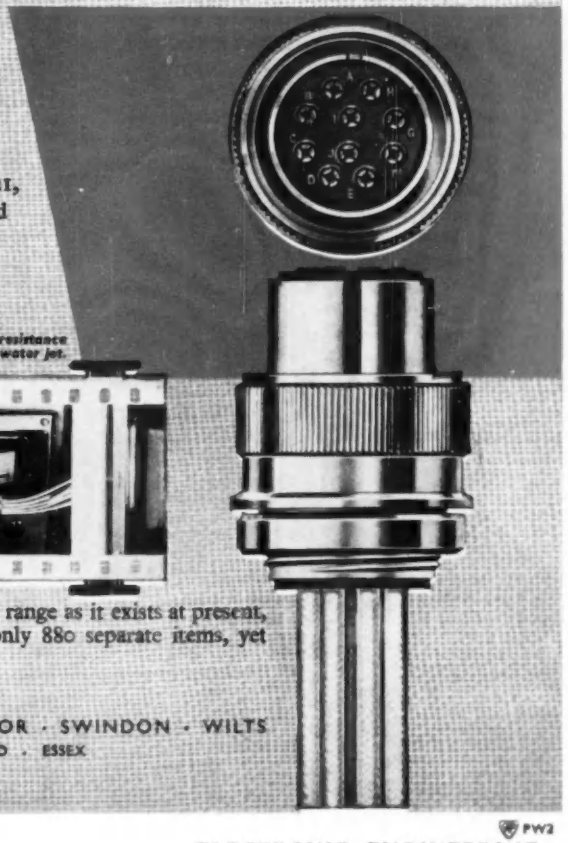
A new Plessey range of Plugs and Sockets

COVERING THE ENTIRE 'AN' RANGE

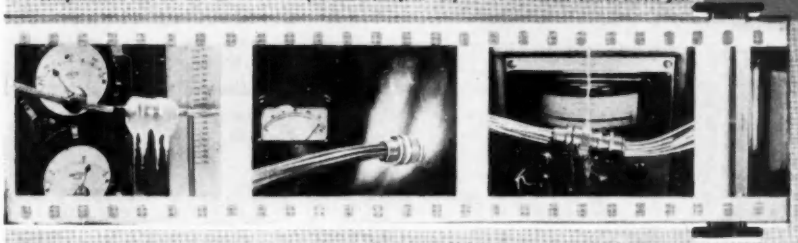
The Plessey UK–AN series of electrical connectors is now available and, for the first time from a non-dollar source, manufacturers will be able to obtain a full range of plugs and sockets completely interchangeable with the existing AN range.*

The Plessey UK–AN range has been designed and developed to M.O.S. Specification EL 1884 and RCS 321, and every UK–AN connector is fireproof, pressure sealed and environmental resisting. No separate wiring accessories are needed.

Write for test reports and full technical details.



Thawing out after low-temperature test at -60° C. *Fireproofness test (15 mins. at 1,100° C.)* *Testing insulation resistance under direct water jet.*



* There are many thousands of separate items in the AN range as it exists at present, whereas the ingenious Plessey UK–AN list comprises only 880 separate items, yet achieves the same service requirements.

ELECTRICAL CONNECTORS DIVISION

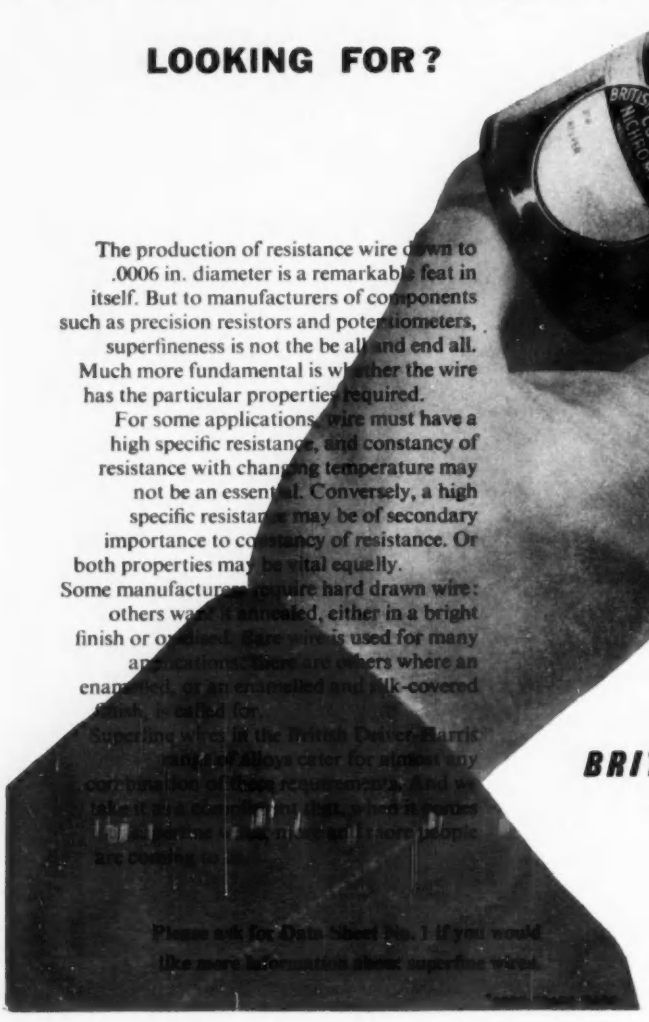
THE PLESSEY COMPANY LIMITED · CHENEY MANOR · SWINDON · WILTS

Overseas Sales Organisation: PLESSEY INTERNATIONAL LIMITED · ILFORD · ESSEX

PW2

EE 3062 *for further details*

WHAT PROPERTIES ARE YOU LOOKING FOR?



The production of resistance wire down to .0006 in. diameter is a remarkable feat in itself. But to manufacturers of components such as precision resistors and potentiometers, superfineness is not the be all and end all. Much more fundamental is whether the wire has the particular properties required.

For some applications, wire must have a high specific resistance, and constancy of resistance with changing temperature may not be an essential. Conversely, a high specific resistance may be of secondary importance to constancy of resistance. Or both properties may be vital equally.

Some manufacturers require hard drawn wire: others want it annealed, either in a bright finish or oxidised. Bare wire is used for many applications. There are others where an enamelled, or an enamelled and silk-covered finish is called for.

Superfine wires in the British Driver-Harris range of alloys cater for almost any combination of these requirements. And we take it as a compliment that, when it comes to superfine wires, more and more people are coming to us.

Please ask for Data Sheet No. 1 if you would like more information about superfine wires.

THESE ARE THE ALLOYS

NICHROME* & NICHROME* V Nichrome* (65/15 type nickel-chromium-iron) and Nichrome* V (80/20 type nickel-chromium) are the alloys most suitable where a high resistance is necessary and where the change in resistance due to temperature does not hinder satisfactory performance.

KARMA* This is essentially a modified 80/20 nickel-chromium alloy, developed especially for the electronics industry, which combines a high specific resistance with a low temperature coefficient.

ADVANCE* Wires of this 60/40 copper-nickel alloy have a low temperature coefficient and a fairly high resistance—important properties in precision resistors which must have constant resistance over a wide temperature range.

BRITISH DRIVER-HARRIS CO LTD

CHEADLE HEATH, CHESHIRE

1908-1958
50 years
ACHIEVEMENT IN ELECTRICAL ALLOYS

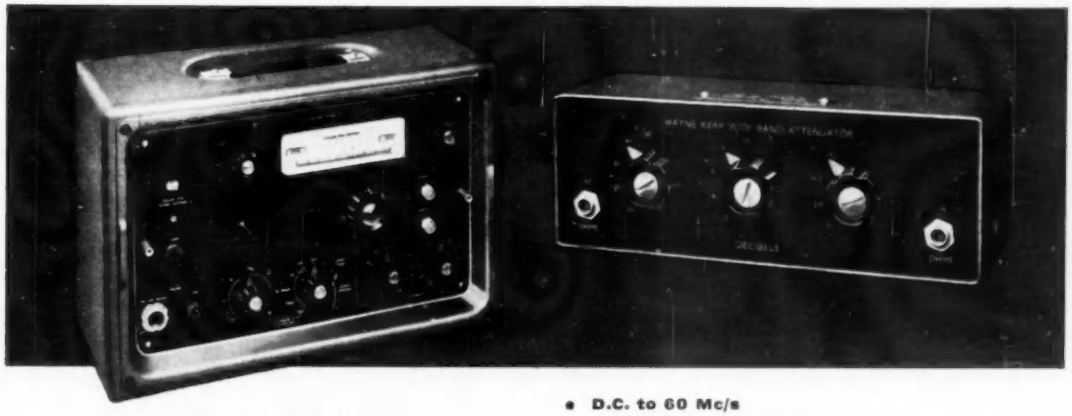
GOLDEN JUBILEE 1958

WAYNE KERR INTRODUCE

Two new instruments

WIDE RANGE AUDIO OSCILLATOR S.121

WIDE BAND ATTENUATOR Q.251



- **Rapid Frequency Selection**
- **High Stability**
- **Low Distortion**

The S.121 is a high grade instrument providing a stable signal of very low harmonic content within the frequency range 10c/s—120kc/s.

The dial display is designed for simple and rapid operation and permits either the selection of major intervals by means of switches, or the continuous fine control of frequency on an open horizontal scale.

Two alternative outputs are provided. A step attenuator covers +10dB—70dB in 1dB steps on a reference level of 1 milliwatt into 600 ohms. The second output provides a continuously variable voltage from 0—30V in five decade ranges. The stability of the output level is ±0·2dB over the whole frequency range. Despite its high performance the instrument is compact, light and portable.

- **D.C. to 60 Mc/s**
- **0—60dB in 0·5dB steps**
- **75Ω Characteristic Impedance**
- **Accuracy D.C. to 20Mc/s 0·1dB, 60mc/s 0·3dB**

A light, compact, variable attenuator for use in the frequency range 0—60Mc/s. The instrument, which has a high performance, is rigidly constructed and is suitable for bench use or as a unit for incorporation in laboratory and test equipment. **PRICE £30**

SPECIFICATION OF AUDIO OSCILLATOR S121

MAINS INPUT
110/120V or 200/250V, 50/60c/s.

FREQUENCY
Range: 10c/s to 120kc/s.
Accuracy: ±1%±0·5c/s.

OUTPUT
1. 600Ω unterminated
2. 600Ω terminated
3. 0 to 30V variable impedance source.

OUTPUT LEVEL
Stability: 600Ω output±0.2dB

WAVEFORM DISTORTION
300c/s to 20kc/s <0.2%,
10c/s <2·5%, 100kc/s <0.4%

HUM LEVEL
<—60dB below fundamental

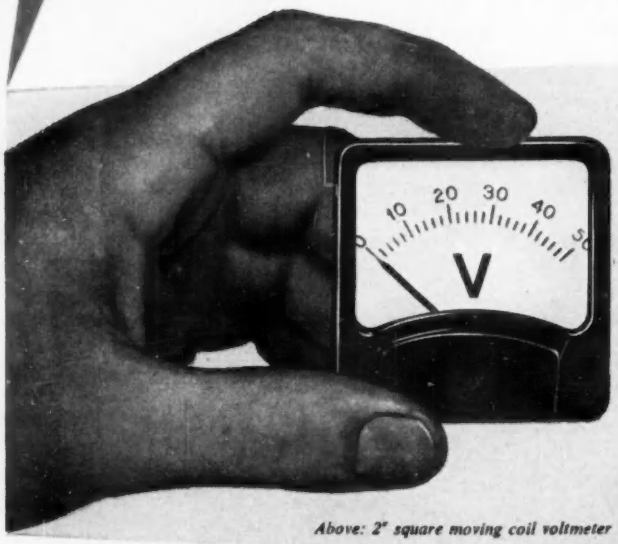
WEIGHT 17 lbs.

PRICE: £130

WAYNE KERR

WAYNE KERR LABORATORIES LIMITED, ROEBUCK ROAD, CHESSINGTON, SURREY. TELEPHONE: LOWER HOOK 1131

A NEW RANGE OF *"Miniature" Instruments*



Above: 2" square moving coil voltmeter

★ **DESIGNED TO HARMONISE WITH ALL MODERN ELECTRONIC EQUIPMENT**

★ **FIXINGS CONFORM TO ACCEPTED PRACTICE**

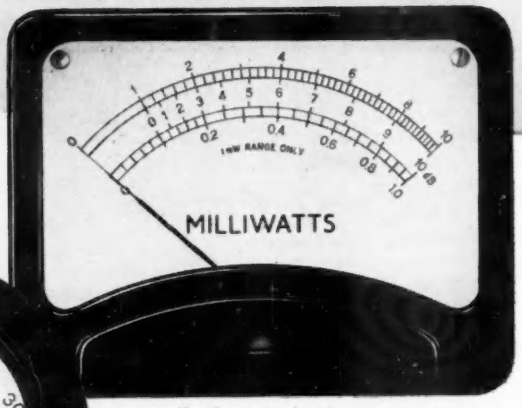
★ **PRICES ARE HIGHLY COMPETITIVE**

For utmost reliability all 'ENGLISH ELECTRIC' miniature instruments have been designed with a higher-than-normal torque/weight ratio in combination with lower power consumption. All types have been successfully subjected to the following tests:

RESISTANCE TO IMPACT SHOCK OF 200g in any plane.

VIBRATION FATIGUE TEST—two million cycles at peak resonant frequency.

OSCILLATORY TEST—up to one million operations.



Above: 3"x 4" rectangular absorption wattmeter

SPECIFICATIONS B.S. 89–1954 and other International Specifications.

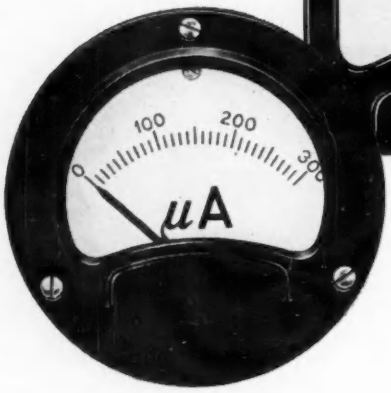
TYPES

Moving coil for D.C. applications.
Rectifier moving coil for A.F. applications.
Thermo-couple operated moving coil for R.F. applications.

SIZES

Square: 2", 2½" and 3½" nominal scale length.
Round: 2½" and 3½" nominal scale length.
Rectangular: 5"x 6" or 3"x 4" nominal case size.

Design registrations pending.



Left: 2½" round moving coil microammeter

Over 50 standard ranges in any of the seven case types.

Delivery ex stock for standard ranges.

Non-standard ranges to customer's specification within 21 days.

Literature available on request to The ENGLISH ELECTRIC Company Ltd., Instrument Department, Stafford.

'ENGLISH ELECTRIC'

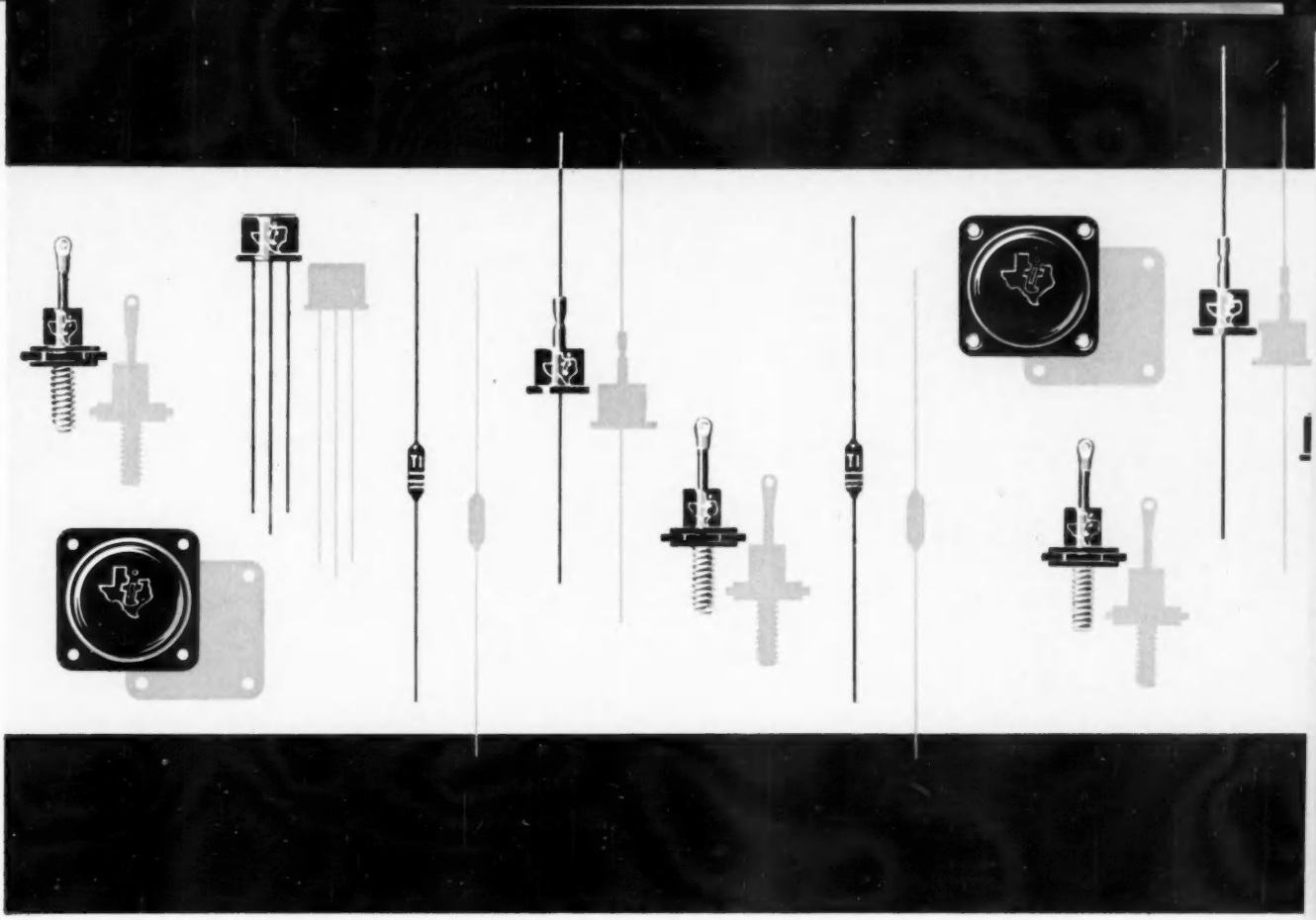
THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

Meter, Relay and Instrument Division, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

EWS.43C8

If the semiconductor data sheet has been detached please write for a further copy as these movements sometimes



TEXAS INSTRUMENTS LIMITED

Pioneers of Semiconductors

DALLAS ROAD, BEDFORD

SILICON TRANSISTORS
125 mW
to 37.5 watts.

SILICON RECTIFIERS
400 mA to 3 amp
and
200 to 600 volts.

TRANSISTORS
to amplify
at 70 Mc/s.

All available
in quantity
from Bedford.

See data
overleaf.
Application Reports
on request.

N-P-N SILICON TRANSISTORS

All maximum ratings refer to a case temperature of 25°C., except where stated otherwise.

All units are capable of storage or operation at temperatures within the range −50°C. to +150°C.

This revised summary sheet incorporates improvements made in the specifications since the previous issue.

	Type No.	U.S. E.I.A. No.	MAXIMUM RATINGS: Collector Dissipation (watts) at 25°C.	MAXIMUM RATINGS: Collector Dissipation (watts) at 100°C.	MAXIMUM RATINGS: Max. I_C (mA)	MAXIMUM RATINGS: Minimum Collector Breakdown (volts)	CHARACTERISTICS: Small Signal Current Gain h_{fe} Min.	CHARACTERISTICS: Small Signal Current Gain h_{fe} Max.	CHARACTERISTICS: Minimum Alpha Cut-off Frequency (Mc/s)	CHARACTERISTICS: Max. I_{co} at 30 v. (μA)	CHARACTERISTICS: Typical Collector Saturation Resistance (ohms)
SMALL SIGNAL	2S001	2N332	0.15	0.10	25	45	9	20	4	0.03††	140
	2S002	2N333	0.15	0.10	25	45	20	40	4	0.03††	140
	2S003	2N334	0.15	0.10	25	45	20	40	10	0.03††	140
	2S004	2N335	0.15	0.10	25	45	36	90	4	0.03††	140
	2S005	2N338	0.125	0.05	20	40	45*	150*	20	1	100
	2S014	2N337	0.125	0.05	20	40	20*	55*	10	1	100
H. F. TETRODES	3S001	3N33	0.125	0.05	10	30	Power Gain: 18 db (min.) at 12.5 Mc/s.				
	3S002	3N34	0.125	0.05	10	30	Power Gain: 16 db (min.) at 30 Mc/s.				
	3S003	3N32	0.125	0.05	10	30	Power Gain: 20 db (min.) at 4.3 Mc/s.				
	3S004	3N35	0.125	0.05	10	30	Power Gain: 20 db (typ.) at 70 Mc/s.				
MEDIUM POWER	2S017	2N497	4	2.25	200	60	12**	36**	0.2†	10	20
	2S018	2N498	4	2.25	200	100	12**	36**	0.2†	10	20
HIGH POWER	2S012	2N389	37.5	15	2A	60	10**	30**	0.3†		4
	2S013	2N424	37.5	15	2A	60	10**	30**	0.3†		7

* D.C. Current Gain.

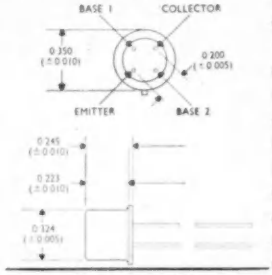
** Large Signal Current Gain.

† Typical Beta Cut-off Frequency.

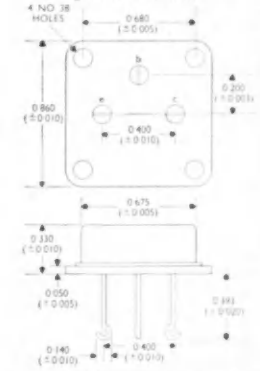
†† Typical Value of I_{co} at Vc = 5v.

Dimensions in inches

Small signal, tetrode and medium power transistors.
Lead configuration for the tetrode is illustrated. For small signal and medium power transistors base lead No. 2 is not used.



High Power Transistor



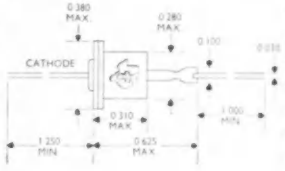
SILICON DIODES AND RECTIFIERS

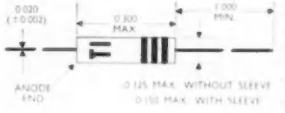
	Type No.	U.S. E.I.A. No.	MAXIMUM RATINGS: Peak Inverse Voltage (volts)	MAXIMUM RATINGS: Average Rectified Forward Current	MAXIMUM RATINGS: Recurrent Peak Forward Current	MAXIMUM RATINGS: Surge Current Rating	SPECIFICATIONS: Maximum Reverse Current at P.I.V. at 25°C.	SPECIFICATIONS: Maximum Forward Voltage Drop at 25°C.
METAL CASE	1S001	1N538	200	750 mA at 25°C 500 mA 100°C	2.5 Amps at 25°C	15 Amps for 5 msec at 25°C	10 μA	1.0 volts at 500 mA
	1S002	1N539	300					
	1S003	1N540	400					
	1S004	1N1095	500					
	1S005	1N1096	600					
GLASS SEAL	1S111	1N645	200	400 mA at 25°C 250 mA at100°C	1.25 Amps at 25°C	5 Amps for 5 msec at 25°C	0.2 μA	1.0 volts at 400 mA
	1S112	1N646	300					
	1S113	1N647	400					
	1S114	1N648	500					
	1S115	1N649	600					
STUD MOUNTING	1S401*	1N1124*	200	†3 Amps at 25°C †2 Amps at 100°C	†10 Amps at 50°C	25 Amps for 5 msec at 25°C	10 μA	1.1 volts at 1 Amp
	1S402*	1N1125*	300					
	1S403*	1N1126*	400					
	1S404*	1N1127*	500					
	1S405*	1N1128*	600					

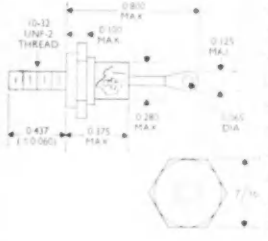
† Rectifier mounted on 2 in. by 2 in. heat sink of $\frac{1}{16}$ in. aluminium.

* Addition of suffix "R" to type number indicates reverse wafer with anode connected to stud.

Dimensions in inches







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Texas Instruments reserves the right to make changes at any time in order to improve design.

NOVEMBER 1958

EE 3065 *for further details*

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This lavish 52 page, full-colour catalogue contains the answers to almost every metal case problem. It tells you all about the famous Imhof range of cases, racks, consoles, handles and accessories—any of which can be supplied in quantity at 7 days' notice. Also it gives full details of IMLOK, the unique low-cost construction system, and SAVILE cases 'tailor-made' from Imlok to individual specification. Make sure of your free copy—POST COUPON NOW!

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type S0530/5, model C

output 1 to 10 kV at 2 mA. Model A
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3 to 30 kV at ½ mA. Model C
input 200/250 volts, 50 cycles
polarity positive or negative grounded available
regulation against full load: better than 0.5%
against mains variations: +5%,—10%. Better than 1%

- 5″ Ernest Turner movement
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- as supplied to A.E.R.E. Harwell, I.C.I., B.B.C., Mullard Research Laboratories, R.R.E. Malvern, Pye Group, Marconi Instruments and Cavendish laboratories

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50 kilovolt regulated supply

Model S0550

output 50kV at ½mA
input 200/250 volts
polarity positive or negative grounded available
regulation against full load: better than 1%
against mains variation: +5%,—5%. Better than 1%
dimensions W: 25½″ H: 23″ D: 11½″

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Model 3C/FN

A valuable Aid for Industrial Research

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Advances in magnetic tape recording—particularly in the use of twin staggered heads—have aroused considerable interest among many of those engaged in medical, physical, aeronautical and other branches of scientific research. The Ferrograph Series 3C/FN, illustrated here, has been specially developed as the result of close co-operation with research workers in many industrial fields, not only in this country but in laboratories throughout the world.

Besides its normal ability to record and playback time pulses on one track and intelligence on the other, there are many additional applications when comparative measurements, stereophonic sound, or, indeed, any two activities capable of being translated into electrical phenomena (within its frequency and phase shift limitations) can be recorded simultaneously for future study and application. Experience has shown that the scope of such an instrument when used for Research purposes is almost unlimited.

Full specification of Model 3C/FN—which is not for domestic use—available on application. Illustrated leaflet GA 767, describing all other Ferrograph Tape Recorders, will be sent on request.

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You did me a good turn—thanks for the tip about Pullin.
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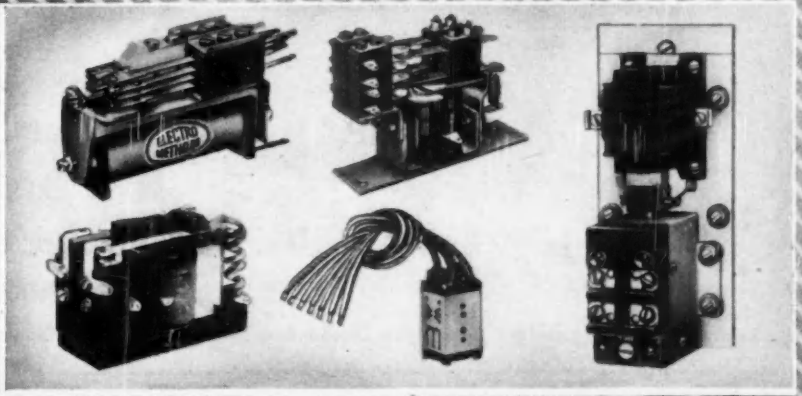

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EE 3070 *for further details*

A RANGE OF TRANSISTORISED REGULATED SUPPLIES

WITH THESE FEATURES · ·

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* **OVERLOAD PROTECTION**—latching relay ensures unit cut out on overload. Fuses protect unit against component failure.

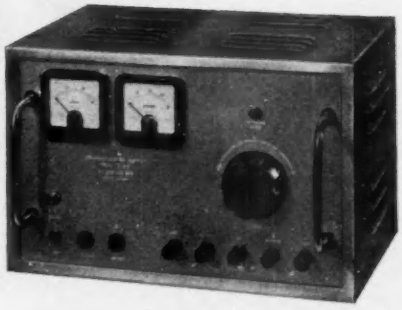
LOW TEMPERATURE RISE—exclusive use of C core transformers.

* **METERS**—grade 1 E. TURNER ammeter and voltmeter.

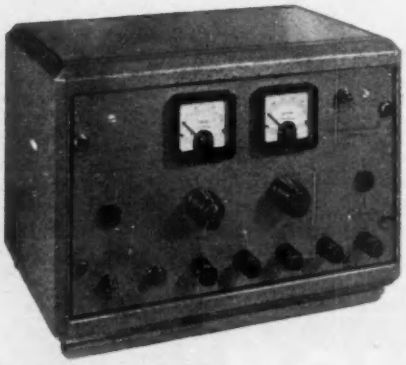
WORKMANSHIP—to highest standards, **ROBAND** standards.

PERFORMANCE—IMPEDANCE: <0.05 ohm
RIPPLE: <1 m.V
OUTPUT VARIATION: Less than 1 part in 1200 for 7% mains change.

MAINS—200/250V. A.C. (115V models available)



MODEL T102.	0-30V at 2A
SIZE:	16⅛" x 8" x 10¼" high
WEIGHT:	35½ lbs.
PRICE:	£85 ex-works



MODEL T101.	0-50V. at 1A
SIZE:	13⅛" x 9" x 9¼" high
WEIGHT:	17 lbs.
PRICE:	£85 ex-works

MODEL T103.	0-30V. at 1A
SIZE:	13⅛" x 9" x 9¼" high
WEIGHT:	17 lbs.
PRICE:	£75 ex-works

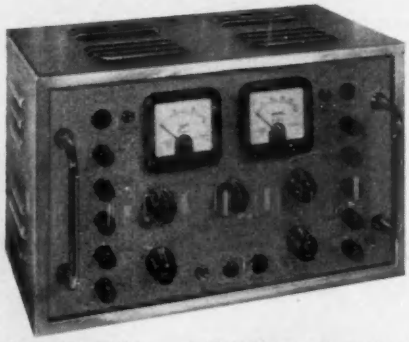
SUB-UNIT T SERIES

SIZE:	7¼" x 4" x 5½" high
WEIGHT:	5 lbs.
PRICE:	£45 ex-works

Supplies any fixed voltage between 0 and 30V at 1 Amp max. Order as T/Required Voltage, for example, T/24 for 24V output.

Any unit can be changed to any other voltage within the range by simply changing the transformer secondary tap and one resistor.

(★ Not applicable to sub-unit)



MODEL T104.	0-30/0-30V, each section 1A
SIZE:	16⅛" x 8" x 10¼" high
WEIGHT:	35½ lbs.
PRICE:	£118 ex-works

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EE 3071 *for further details*

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The experience gained in manufacturing quartz crystals to the stringent requirements of our own apparatus and of Service equipment enables us to offer a comprehensive range of crystals covering the frequency band 1.6 Kc/s to 55 mc/s at extremely competitive prices.

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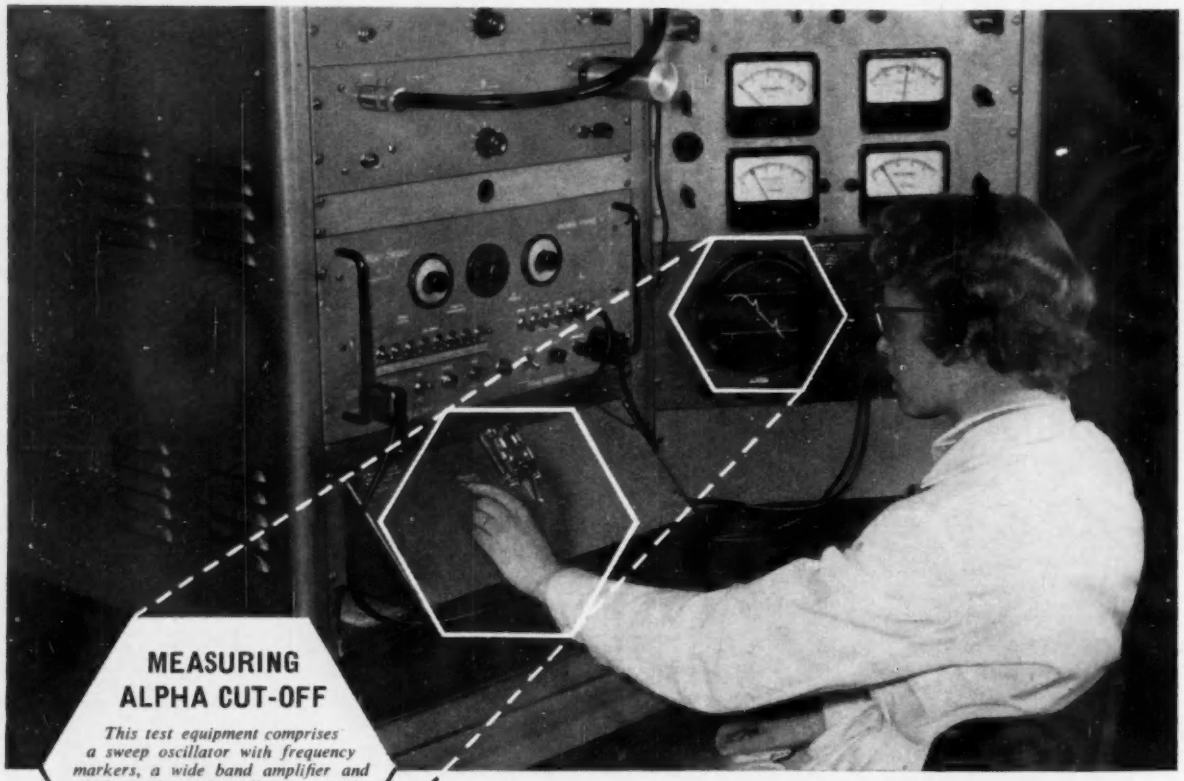


MEASURING ALPHA CUT-OFF

This test equipment comprises a sweep oscillator with frequency markers, a wide band amplifier and C.R. display giving 3db points: with it, an accurate, visual measurement of alpha cut-off is obtained. All Texas small signal transistors are tested in this way.

NEW V.H.F. TRANSISTOR to give 18 db gain at 70 Mc/s

These new Texas silicon tetrodes combine high gain with stability and interchangeability. They make it possible to transistorise V.H.F. equipment now.

Actual Size

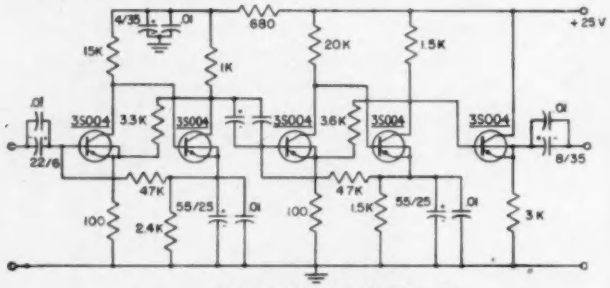
MAXIMUM RATINGS

Collector dissipation at 25°C.	125 mW
Collector dissipation at 100°C.	50 mW
Collector Breakdown voltage	30 volts
Collector current	10 mA

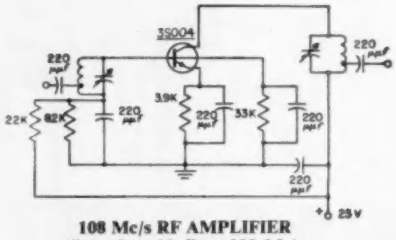
SPECIFICATION

Type No.	*Power Gain*
3S002 (3N34)	16 db (min) at 30 Mc/s.
3S004 (3N35)	18 db (min) at 70 Mc/s.

TWO CIRCUIT EXAMPLES



10 Mc/s VIDEO AMPLIFIER
Measured Power Gain, 53 db. Bandwidth 10 Mc/s. Load Used, 470 Ohms.



108 Mc/s RF AMPLIFIER
Gain, 8 to 11 db at 108 Mc/s Unneutralized.

TEXAS INSTRUMENTS LIMITED

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T19

To make better transformers at lower cost is always our objective. Both aims are achieved in the COMMODORE series, awarded Full Inter-Service Approval Certificate No. 812/9. The 3-piece housing enables internal leads to be kept short, which, with the reduced number of internal joints and the prepositioning of leads, provides greater reliability. That the terminals may also be fitted to the base and even the sides of the transformer, offers still greater versatility. For twenty years Gresham engineers have been improving the design and construction of transformers. The COMMODORE series is further evidence of the Gresham background of knowledge and skill.

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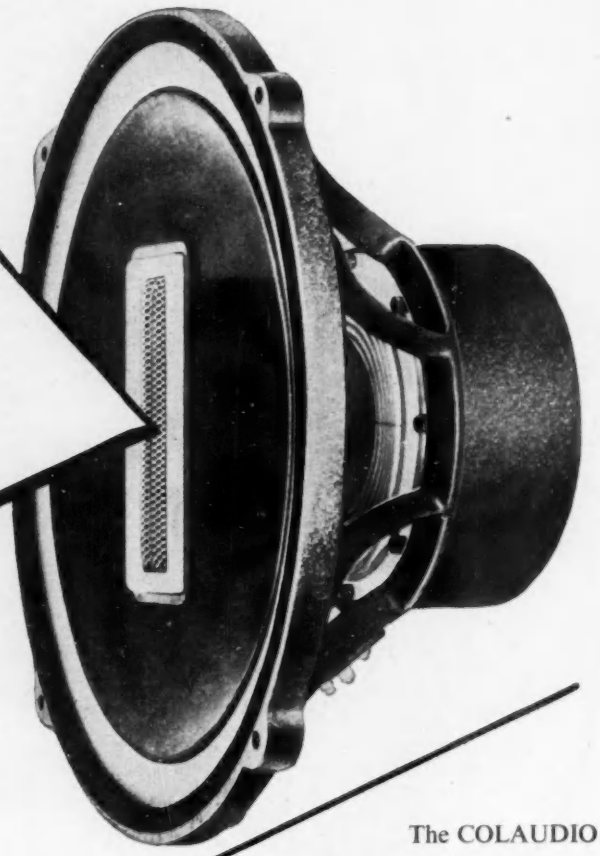
TRANSFORMERS LTD

ELECTRONICS DIVISION
LION WORKS *HANWORTH* Middx

. . . a new approach to better listening



The COLAUDIO provides a new incentive to listening, creates a new realism in reproduced sound, adds a new beauty to music and the finer nuances of speech. Combining a 15 in. direct radiator bass loudspeaker with two direct radiator, pressure-type high frequency reproducers in column form, the COLAUDIO is the culmination of over thirty years research, development and manufacture of loudspeakers for all purposes. Its perfection of tone can be truly appreciated only by an aural test — once heard, you will never be satisfied until you install one in your own reproducing equipment.

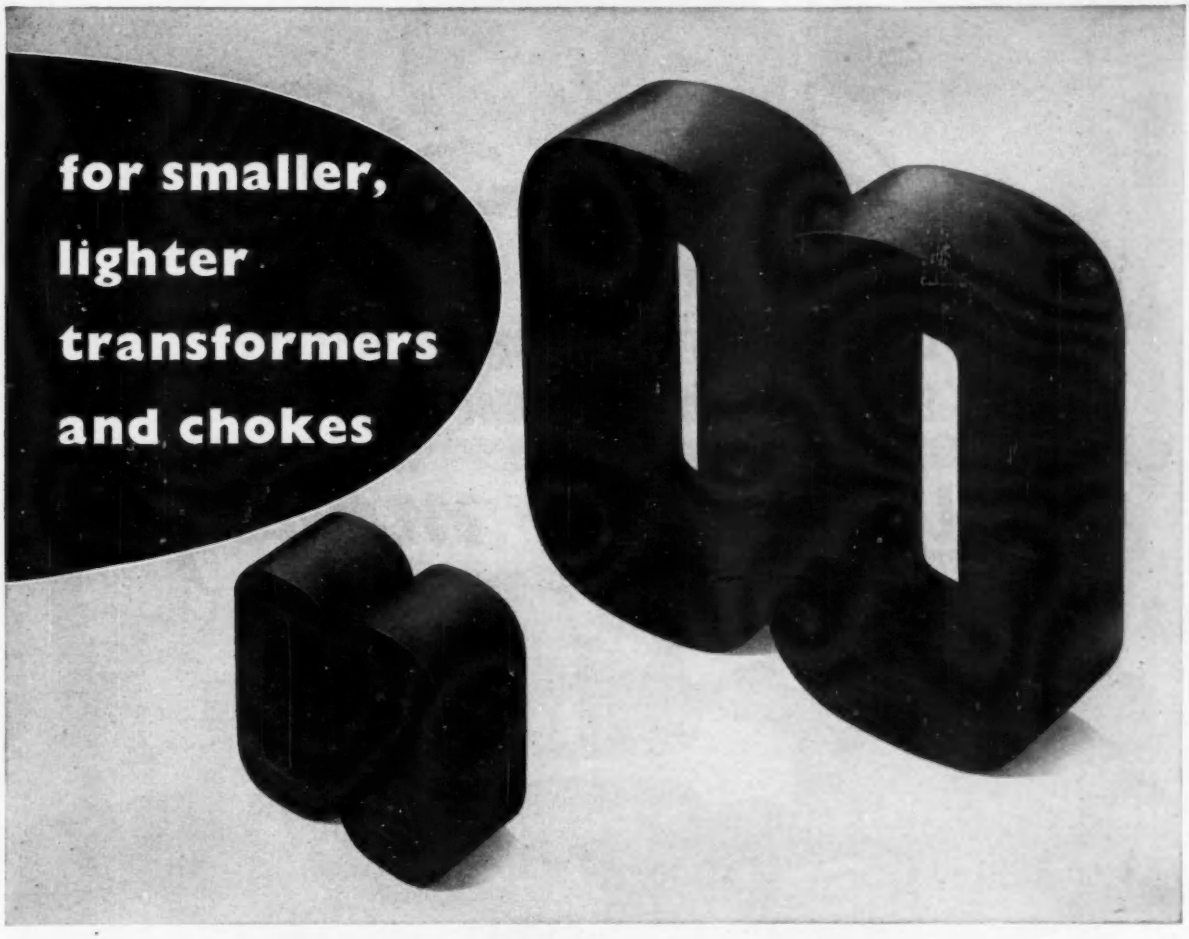
ESSENTIAL DATA

Nominal Size	15"
Peak Power Handling Capacity	25 watts
Voice Coil Diameter	3"
Total Flux	290,000 Maxwells
Frequency Response	30-15,000 c/s
Bass Resonance	35 c/s
Impedance at 400 c/c ...	15 ohms

CELESTION

COLAUDIO

Rola Celestion Ltd. THAMES DITTON, SURREY, ENGLAND. *Emberbrook 3402/6*



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- ★ Transformers are up to 30% smaller and lighter.
- ★ Transformers have lower losses, lower magnetising VA and lower leakage flux.
- ★ Cores are suitable for oil-filled, open type or "resin cast" transformers.
- ★ Cores are stable up to 250°C.

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'C' CORES

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Transformer Department, Liverpool
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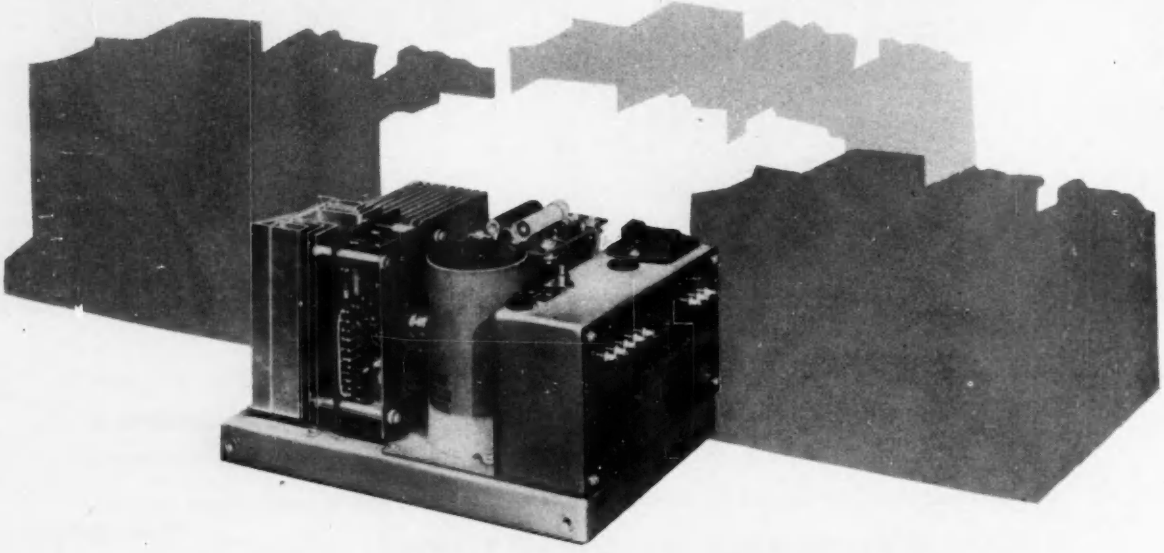
TFL33JB

EE 3076 *for further details*

at £39

the Servomex variable voltage transistorised power unit

saves You money!



and it's ready for building into your own equipment -

In the D.C.65, SERVOMEX production techniques combine with semi-conductor circuits to give a faster control and a lower price. **Further details of performance are given in Data sheet D.C.65 obtainable on request.**

- **Output 6-14 volts 0-1 Amp**
- **Stabilisation factor 600**
- **Price £39 delivered in U.K.**
- **Output resistance < 15mΩ**
- **Response time < 100μ S.**

SERVOMEX

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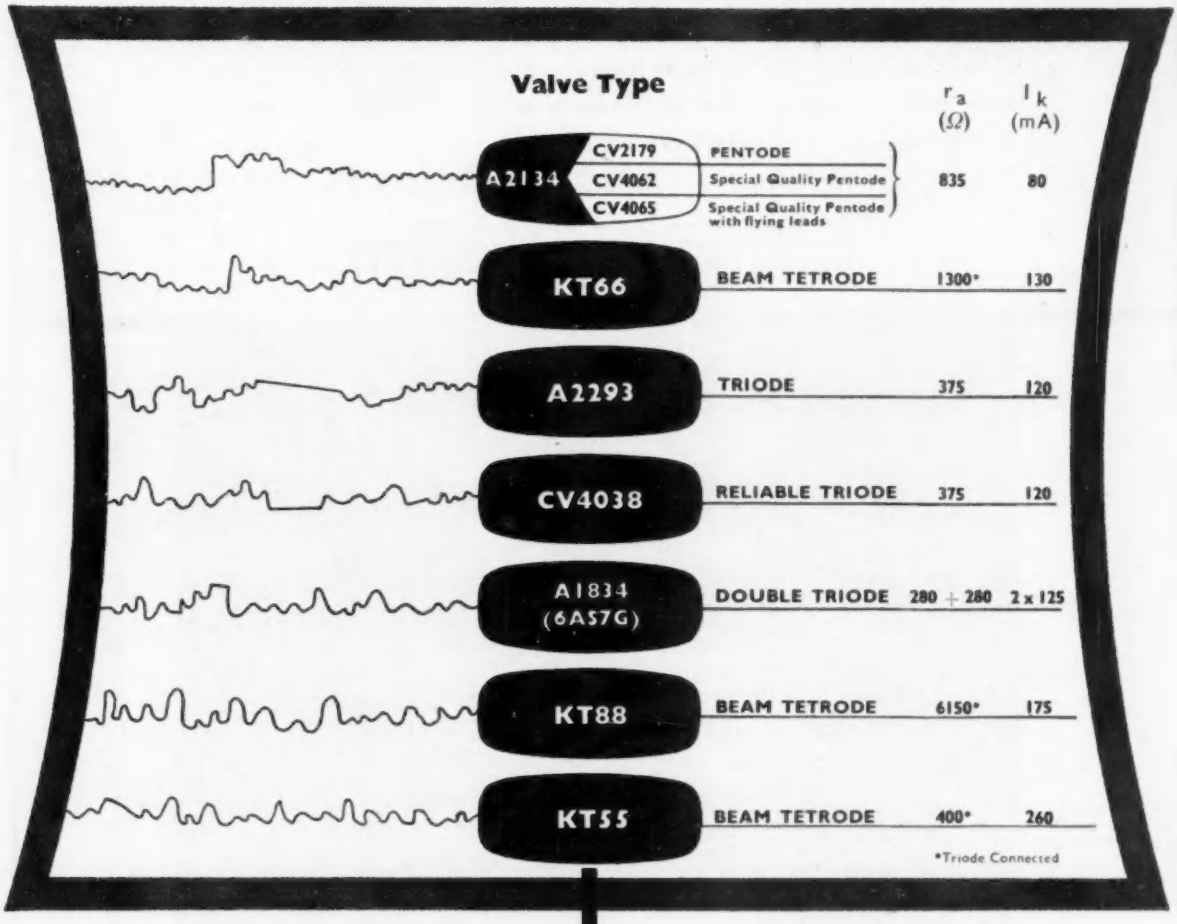
EE 3077 *for further details*

G.E.C.

Series Stabilisers

The M-O Valve Company Limited—the specialists in the development and manufacture of valves and cathode ray tubes for industry—supplies a wide range of valves, suitable for use as series stabilisers.



Details of the wide range of the Company's products, including valves and CRTS, are given in a new catalogue which will gladly be sent on request.

GENERAL SHEET 4

An informative data sheet which describes the design and operation of series valve stabiliser circuits.
Write now for your copy.

M-O VALVE COMPANY LIMITED, Brook Green, Hammersmith, London, W.6

MAKERS OF G.E.C. HIGH GRADE RADIO VALVES AND CATHODE RAY TUBES

a subsidiary of The General Electric Company Limited.

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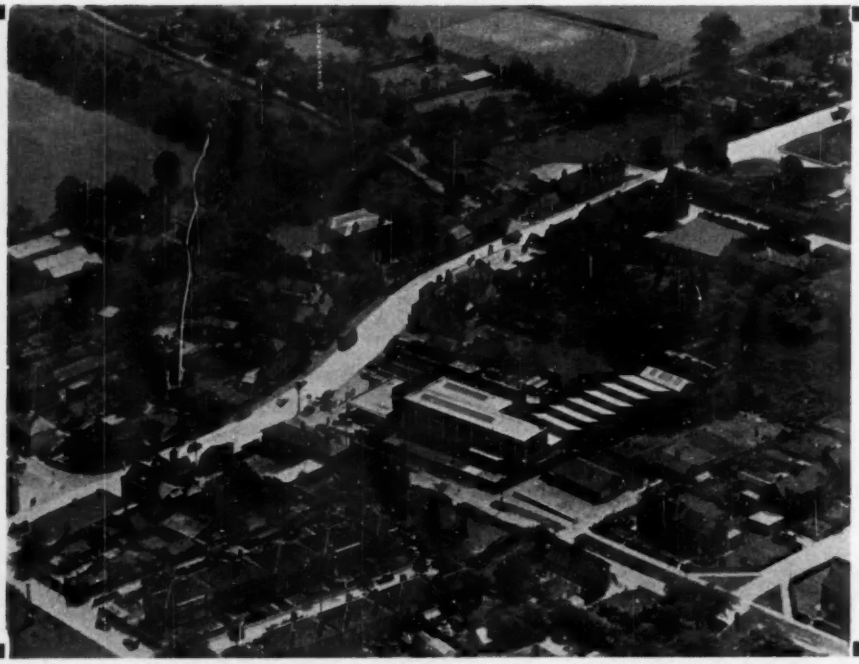
Although only 15 miles from London our "country" location on the main road to Cambridge has helped us to select and train a labour force of enthusiastic and loyal specialists. Most of them have been with us for a number of years and are very much "of the family". This is one reason why we are able to combine low charges and superlative quality of workmanship on all types of electronic assembly and wiring operations. Working on contract for internationally famous concerns, our experience ranges from small sub-assemblies to complete computers. This comprehensive production service often proves cheaper than the loaded factory costs of those who employ us. *And* we never undertake work unless we can guarantee delivery. You cannot lose by asking for a Broxlea quote on your next sticky job.

This picture shows the country setting of our 14,000 sq. ft. factory, barely a stone's throw from the main London-Cambridge road. (Only good manners stopped us saying "within spitting distance!")

TO CAMBRIDGE



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116 SMOOTHING CHOKES*

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ranging from
100h at 10mA
to
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are fully described in the
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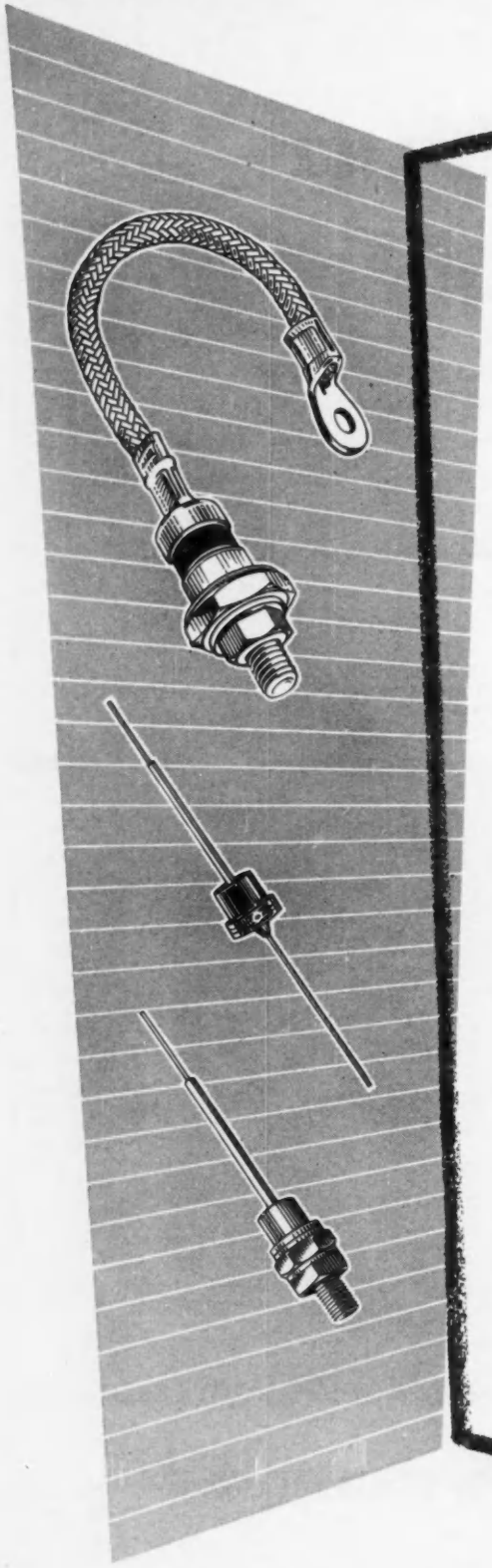

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Ferranti offer a range of hermetically sealed rectifiers with peak inverse voltage ratings up to 300 volts, and rectified current from 100 mA. to 30 amps. from a single convection cooled diode.

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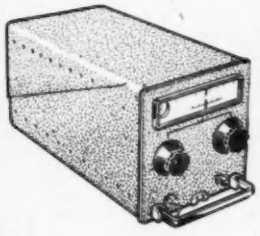
FE185/2

EE 3081 *for further details*

A.W.A
ELECTRONICS

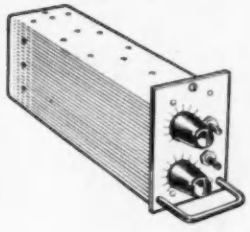
New concepts in electronics have been developed at AWA, as a result of experience with missile systems. Now they have a wider application. Here are some of the new AWA devices now available to industry.



U.H.F. WIDEBAND RECEIVER

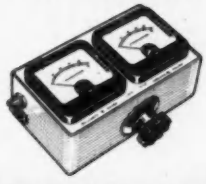
Basic arrangement consists of R.F. amplifier, mixer, local oscillator, I.F. amplifier (A.G.C. controlled), cathode follower output stage. Tuning indicator (EM 34) is also fitted to receiver. The standard forms: one for airborne racking with special separate power supply unit, the other on larger chassis including power supply unit (conventional 19" front panel). *Standard specification: 420-470 M/cs frequency range; 4 M/cs overall bandwidth, approximately 10 db noise factor; approximately 70 ohms input impedance. 200-250 V and 50-60 c/s input supply. Input is unbalanced, output is via low impedance (cathode follower) stage.*

TRANSISTOR GALVANOMETER AMPLIFIER

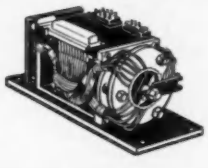


This Amplifier has been designed to drive viscous damped recording galvanometers which normally have a resistance of 50 ohms and a working range of D.C. to 2 Kc/s in frequency. The amplifier has a switched attenuator at its input and will accept single ended or push pull signals from ± 1 Millivolt to ± 500 volts and will feed a maximum of ± 50 Milliamps to the galvanometer. There is also a range of ancillary units available for use with this Amplifier as part of a comprehensive instrumentation system. *Standard specification: Dimensions: 4¼ in. x 3¾ in. x 10 in.; Frequency response: Flat from DC to 2 Kc/s, 5% down at 3 Kc/s, 3db down at 6 Kc/s; Noise level: 10 Microvolts at either input; Input impedance: 40,000 ohms on range 5, 110,000 ohms all other ranges; Gain: Maximum 5 Milliamps/Millivolt, minimum 0.04 Milliamps/Volt; Power requirements: ± 6 Volts D.C. 220 Milliamps each line.*

DIRECTIONAL COUPLER



Of the 'Loop' type, suitable for measurements of RF power and Standing Wave Ratio in coaxial cables. Directional properties are largely unaffected by frequency changes, so coupler may be used to help obtain optimum termination of a 52 ohm coaxial system up to 600 M/cs. *Standard specification: Size 7" x 4" x 2½"; weighs 4 lbs. 3 ozs.; Power Measurement Range is Low range 1 w.cw.max. High range 5 w.cw.max.; less than 1% attenuation; better than 2% accuracy at frequency of calibration.*



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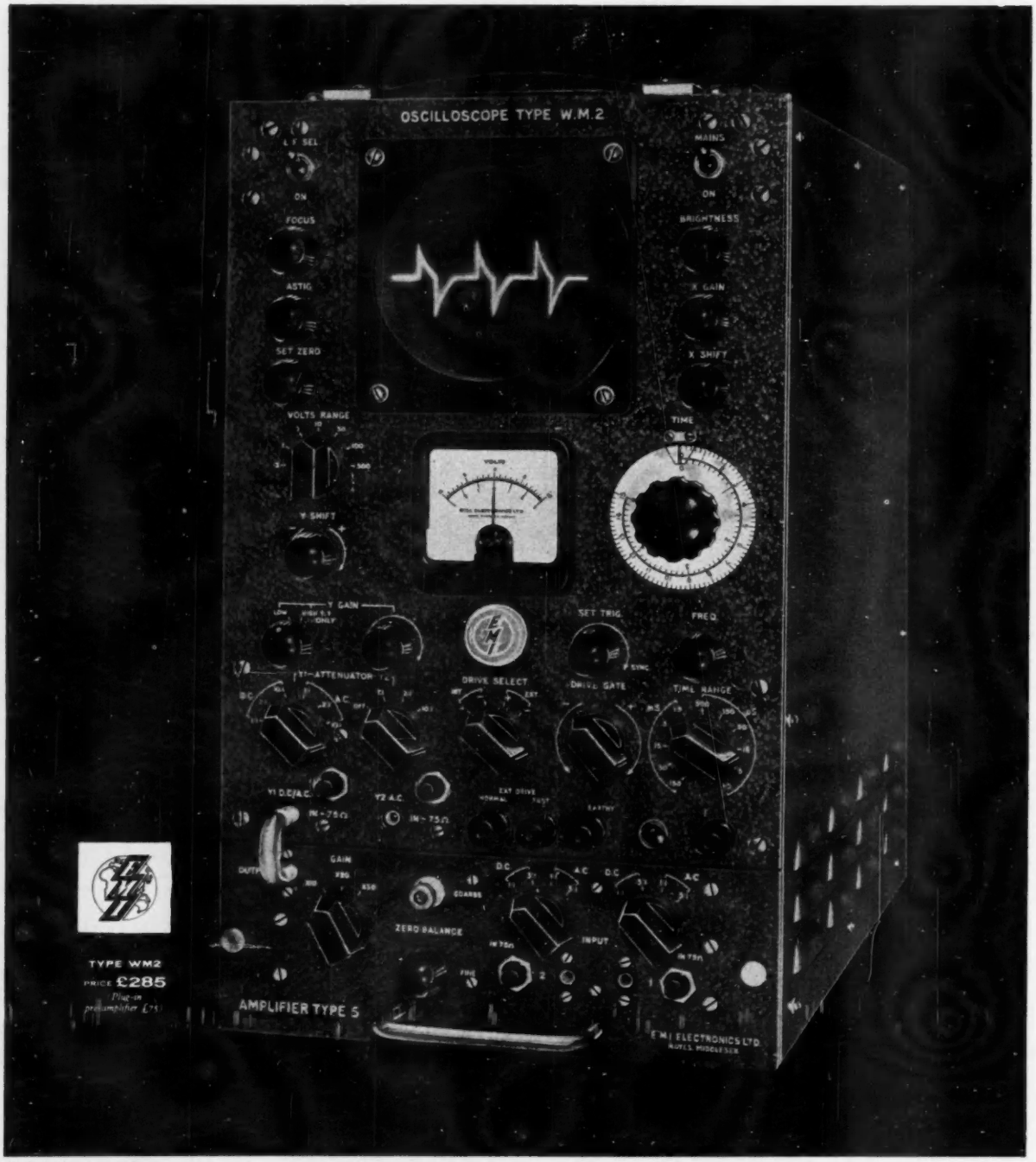
* **Direct time and voltage measurement with 2% accuracy**
* **Built-in signal delay**
* **Bandwidth DC to 12 Mc/s**
* **Y sensitivity at full bandwidth 100 mV/cm**
* **Maximum Y sensitivity 3 mV/cm**
* **Maximum sweep speed 40 cm/µS**



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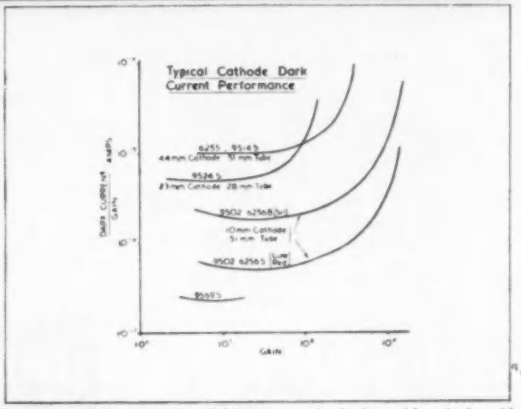
- **High overall sensitivities**
- **High stability**
- **Guaranteed performance**
- **11 and 13 Stage Tubes with glass bases for improved insulation.**
- **10 Stage Tubes with medium shell di-heptal bases**

*** E.M.I. "S" Type Cathode—reduced red sensitivity with greatly reduced thermionic emission, and very low dark current.**



Recent additions to the E.M.I. range include a side window 11 Stage Tube (9569S) of 1½" diameter, a single stage tube (9568S) of ½" diameter, and a high impedance (10^{14} ohm) photocell (25110).

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EE2

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BANDWIDTH AND SENSITIVITY

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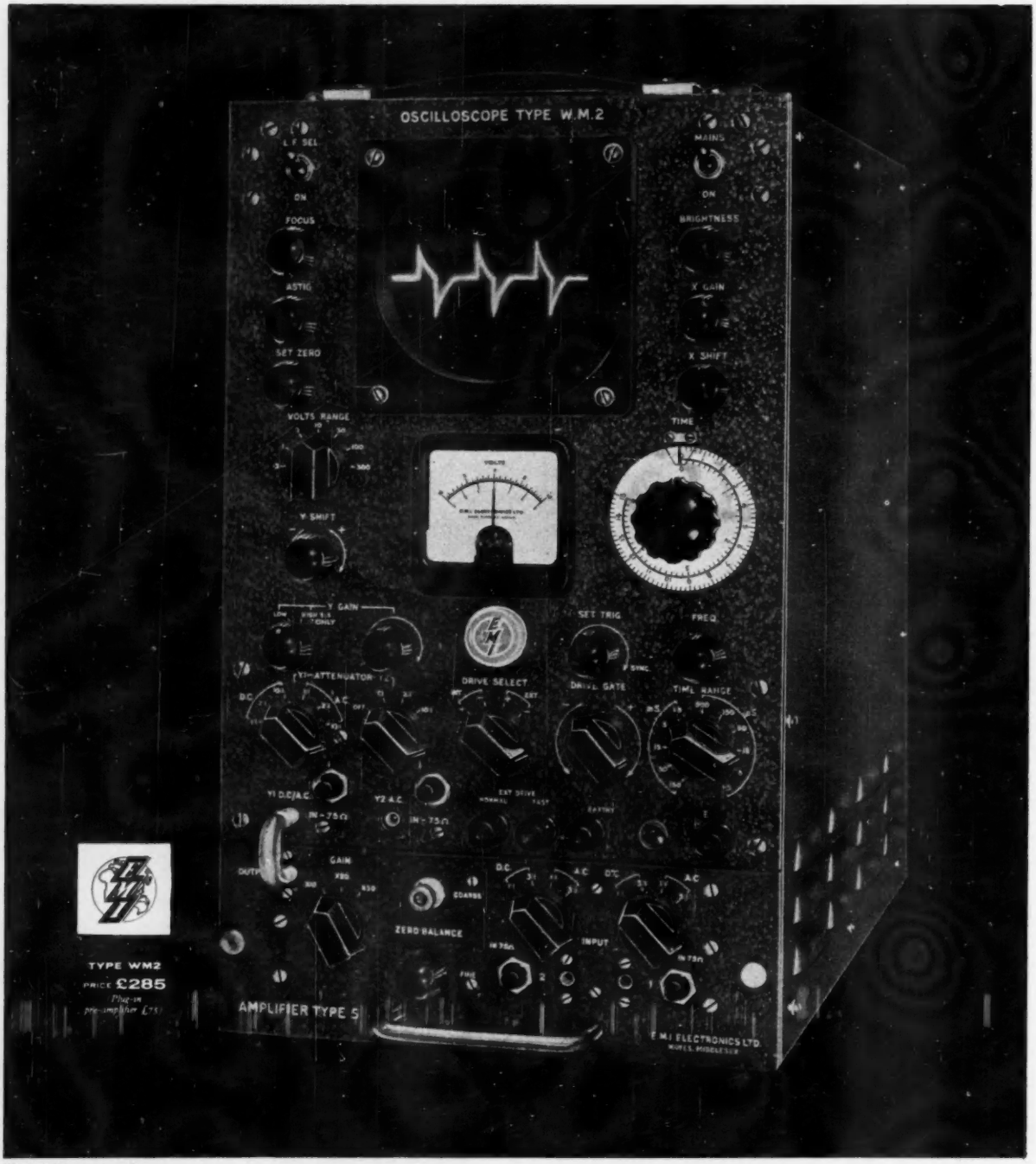
* **Y sensitivity at full bandwidth 100 mV/cm**
* **Maximum Y sensitivity 3 mV/cm**
* **Maximum sweep speed 40 cm/µS**



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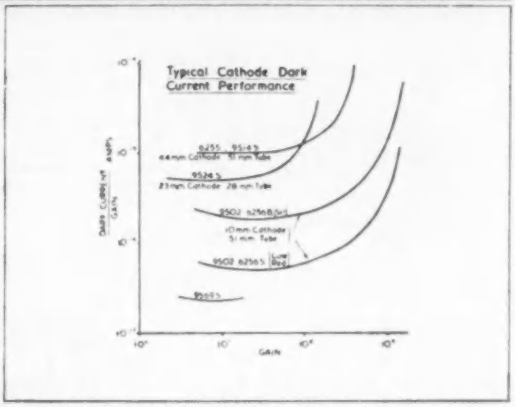

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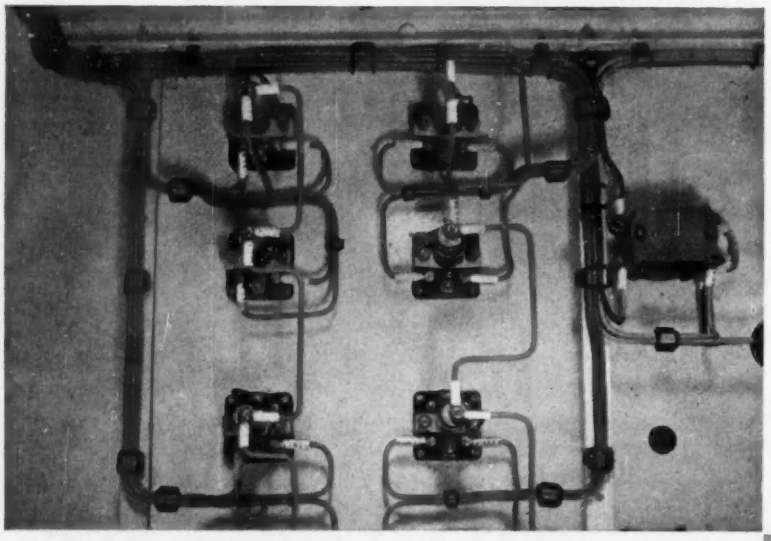

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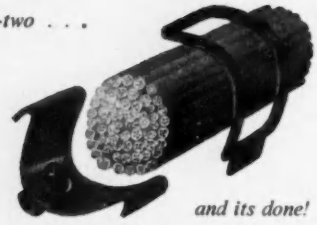
- Brings a new versatility, compactness and neatness to your wiring.
- Completely insulated and suitable for all climates.
- Electrical and mechanical security in all conditions.
- Proved in wiring installations throughout the world.

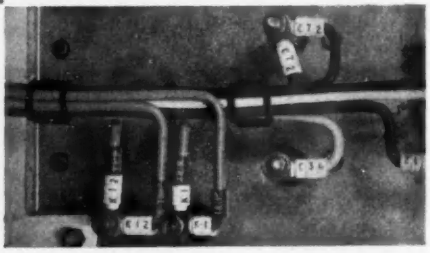
one-two . . .



and its done!

Section of Cubicle Control Board, showing CRADLECLIP.

Close-up of CRADLECLIP installation.



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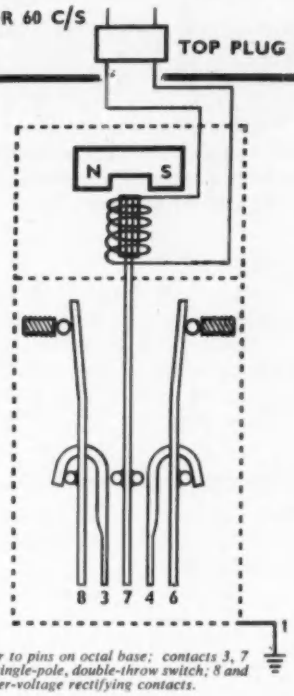
SPURIOUS E.M.F.'s < 1.0μV

LEAKAGE CURRENTS < 10^{-11} Amp



Numbers refer to pins on octal base; contacts 3, 7 and 4 are the single-pole, double-throw switch; 8 and 6 are the higher-voltage rectifying contacts.

SPECIFICATION

CONTACT-SETTING (FOUR TYPES AVAILABLE)

SETTING	% of cycle during which	
	3 and 7 are in contact	4 and 7 are in contact
A	33.3	33.3
B	49.0	49.0
C	57.5	57.5
D	33.3	66.7

POWER SUPPLY AND COIL DATA

Normal working voltage: 6.3V r.m.s. (12V r.m.s. max.)
Frequency: 40, 50, 60c/s ±3c/s
Coil resistance: 115 ohms nominal
Coil inductive reactance at 50c/s: 37 ohms nominal
Normal current: 50 r.m.s. mA
Normal power consumption: 0.3 W

PHASING

The contact operation lags the applied voltage by 25° to 30°, 30° to 35°, and 35° to 40° with 40, 50 and 60 c/s supply frequency respectively.

RATING OF EACH CONTACT FOR d.c. NON-INDUCTIVE CIRCUITS

0.3V 100mA
3.0V 1mA
10.0V 0.1mA

Below 0.1V no electrical erosion occurs.

SPURIOUS EFFECTS

Magnetically induced e.m.f.'s: less than 0.5 r.m.s. microvolts
Thermal e.m.f.'s: less than 1.0μV
Leakage currents: less than 10^{-11} Amp
Contact bounce: negligible

PRINCIPAL DIMENSIONS

Height from chassis to top of plug: 4⅛ in. (105 mm) approx.
Can diameter: 1½ in. (38 mm) approx.
Base diameter: 1¾ in. (45 mm) approx.

PRICE £13.2.0 EACH

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EE 3086 *for further details*

AIRMEC

SIGNAL GENERATORS

HF SIGNAL GENERATOR Type 201

For accurate, stable sinusoidal signals of pure waveform from 30 kc/s to 30 Mc/s. Output levels, which are stabilised by an amplified A.G.C. system, can be varied from 1 microvolt to 1.1 volts R.M.S. (or 2.2 volts R.M.S. unmodulated). A high output of 5 volts (10 volts unmodulated) is also provided from a 300 ohm source impedance. The attenuators are very accurately calibrated and have a constant 75 ohm output impedance, regardless of their setting and the frequency in use.

RANGE

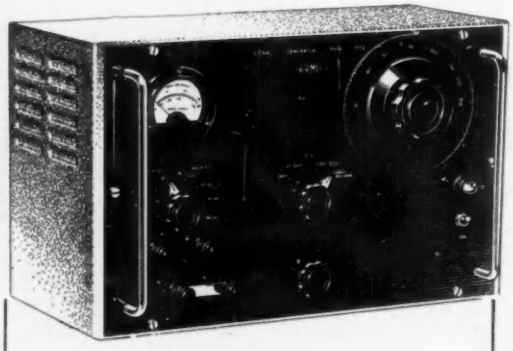
The range from 30 kc/s to 30 Mc/s is divided into 7 bands and a turret switch is used to select the band required. Calibration for each band is displayed directly in frequency, on an illuminated film scale which is approximately four feet long, and which can be corrected by means of a movable cursor against the built in crystal calibrator.

BENCH USE AND FORWARD MOUNTING

The instrument is housed in a robust steel case, which is equally suitable for either forward mounting on a standard 19 in. rack or for bench use.

STATISTICS

• Frequency range 30 kc/s—30 Mc/s • Crystal calibration • Harmonic components less than 1% • Film scale giving actual scale length of 4 ft. on each band • 90 : 1 slow motion drive with logging scale • High output of 5 volts • Output variable from 1 microvolt to 1.1 volts at 75 ohm impedance • Output level constant over entire frequency range • Modulation depth variable from 0-100% • F.M. and A.M. less than 300 c/s.



STATISTICS

• Frequency range 30 c/s—30 kc/s • Frequency stability + 0.25% +0.5 c/s • A screened and balanced transformer enables balanced, unbalanced and fully floating outputs to be obtained • A 600 ohm constant impedance attenuator provides steps of 20, 40 and 60 db of attenuation under all output conditions.

• Delivery—ex stock

LF SIGNAL GENERATOR Type 702

OSCILLATOR

A resistance-capacitance type of oscillator is employed to obtain a stable output waveform with very low harmonic distortion. Such disadvantages as spurious R.F. content in the output signal, and poor frequency stability, which are commonly associated with beat-frequency oscillators, are thereby eliminated.

OUTPUT CIRCUIT

The output circuit of the instrument uses a screened and balanced transformer to enable unbalanced, balanced and floating conditions to be obtained, and a 600 ohm constant impedance attenuator provides steps of 0, 20, 40 and 60 db of attenuation under all output conditions. A single level control is incorporated for setting the output to any desired value, and the amplitude is monitored by a diode valve-voltmeter calibrated both in open circuit volts and in db relative to 1 milliwatt in 600 ohms.

BENCH USE AND FORWARD MOUNTING

The instrument is enclosed in a standard Airmec case and is therefore suitable both for bench use and for forward mounting on a 19-inch rack.

DELIVERY - EX STOCK

Airmec

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Vol. 30
No. 369

NOVEMBER 1958

Electronic Engineering

Managing Editor: H. G. FOSTER, *M.Sc., M.I.E.E.*

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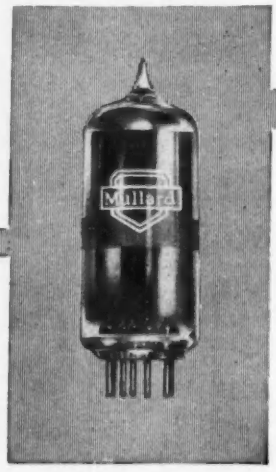

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MVT355

ELECTRONIC ENGINEERING

VOL. 30 No. 369

NOVEMBER 1958

Commentary

THE construction of a 'round-the-world' Commonwealth telephone cable was considered at the recent Commonwealth Trade and Economic Conference and it was envisaged that its provision would be based on capital contributions from all Commonwealth countries and that the new cable would be operated on a self-supporting financial basis. The technical and financial issues arising in connexion with this proposal were examined at a conference of technical representatives from all Commonwealth countries which met in London earlier this year and which examined in detail a scheme for such a cable.

The first transoceanic telephone cable was opened in 1956 between the United Kingdom, Canada and the U.S.A., and the construction of a further cable between Canada and the United Kingdom is expected to be completed in 1961. This would form the first part of the Commonwealth link, the rest of the route being as follows:—The West Coast of Canada would be linked with New Zealand and Australia and from there the cable would run through the Indian Ocean connecting Malaya, India, Pakistan and Ceylon and from these countries by way of Kenya to South Africa; by providing a link between South Africa and the United Kingdom connexion could be made with the Transatlantic telephone cables.

The order of construction is, of course, a matter for further consideration by the Commonwealth Governments, but it may well be that the existing and proposed links from the United Kingdom to Canada would first be extended by a cable from the United Kingdom to South Africa followed by a cable across the Pacific to New Zealand and Australia; the links spanning the Indian Ocean, to be constructed later, would complete the girdle of the world. The total length of such a cable installation would be about 30 000 nautical miles and the estimated cost of construction some £88M.

Although the network is proposed as a Commonwealth project, individual governments will have, obviously, a special interest in different sections of it and it is likely that the various countries concerned will become partners in the ownership of particular sections as they are constructed.

In the 1920's there was considerable rivalry between the protagonists of cable and radio as a means of long distance telegraphic communication. However, the two systems gradually learned to live together in harmony and by the outbreak of war in 1939 they had reached an advanced stage of integration, and Commonwealth communications were secure against anything but a major catastrophe. But when Italy entered the war she immediately cut the Mediterranean cables between Malta and Gibraltar thus disrupting the main cable routes to the Middle East, India, the Far East and Australia. Later on the whole of the Far Eastern cable network was lost to the Japanese. To make good this very severe breach in world telegraphic communications the h.f. communication networks were expanded on an unprecedented scale and radio reigned supreme.

The above remarks apply to telegraphy only of course. As far as telephony is concerned there has been, until two or three years ago, no alternative to radio as a means of long distance transoceanic communication. But now it would seem that we must look to cables rather than to radio to satisfy the future requirements of the ever growing telephone and telex traffic between the Commonwealth countries; for although radio might suffice for a time on some routes where radio transmission is usually good, it does not satisfy even the immediate needs, in terms of quality and regularity of service, for some important Commonwealth services. There would appear to be little likelihood of any technical development in radio communication in the near future that will greatly enhance its performance; but with cable the position is very different for, not only is the design and construction of the cables themselves improving rapidly but also, and perhaps more important, the design of the necessary deep sea repeaters is improving steadily.

The present Transatlantic telephone cable is a twin-cable system, one cable carrying traffic in the westerly direction and the other cable carrying traffic in the easterly direction. Recent developments by the Post Office Research Laboratories in co-operation with the British communications industry have now made it possible to provide both-way connexion for telephone and telex services over a single transoceanic cable, thus conforming with British practice in shallower waters. This development has reached the stage where the engineering planning of an intra-Commonwealth scheme can proceed with this new technique and, indeed, it will be used for the first time in the cable to be laid between Canada and the United Kingdom in 1961. In addition considerable research is being directed towards the evolution of even lighter cables and repeaters using transistors instead of valves, which would be of great advantage from the points of view of size, reliability and, not least, the power supplies required.

The provision of an intra-Commonwealth telephone network of the type envisaged is no small undertaking but it is one which could play a leading part in bonding the member countries closer together and is, fortunately one in which Great Britain is technically equipped to play a leading rôle.

Some Novel Circuits Employing Cold-Cathode Tubes

(Part 1)

By R. S. Sidorowicz*, Dipl.Ing., D.I.C., A.M.I.E.E.

The circuits described are based on three types of cold-cathode tube: (1) a stable subminiature diode, type XC12, (2) a subminiature triode, type XC18, having a current rating of 1·0mA, and (3) a miniature 7·5mA triode, type XC23. The diode is used to stabilize the anode breakdown voltage of the triodes, and this technique leads to the development of a stable relaxation oscillator, a voltage discriminator or a delay circuit and two satisfactory monostable circuits. The 7·5mA tubes are employed in a special bistable circuit and in a univibrator. These circuits are capable of supplying currents of up to 8mA and are used in controlling of the 1·0mA triodes. This technique permits the development of a staircase waveform generator, a rectangular pulse generator, a fast decade counter, a six-tube decade counter and a five-tube decade.

THE aim of this article is to describe a number of novel circuits based on cold-cathode glow discharge tubes. The circuits are referred to as 'novel' not because they perform some novel functions, but on account of their special features. The circuits can be divided into two groups. The first group is characterized by the introduction of certain refinements into a number of standard, well-known circuits. These refinements result in an improvement of the stability and reliability of the circuits. The main feature of the second group is the combining of the tubes of two different sizes, i.e., the tubes whose current ratings differ by about one order of magnitude. The larger tubes in these circuits are employed to control the smaller tubes. The technique has led to the development of a number of novel circuits which have some useful properties.

It is not intended to discuss here the details of the design techniques of the circuits or to determine the optimum values of the circuit components. The reader who may be interested in the design aspects of cold-cathode tube circuits is referred to the papers of G. H. Hough and D. S. Ridler[1], R. Threadgold[2], J. E. Flood and J. B. Warman[3] and G. O. Crowther and K. F. Gimson[4]. Also, the physics of cold-cathode gas discharges will not be dealt with, since ample information on the subject can be found in a number of textbooks[5,6,7,8,9]. It may be useful, however, to consider some general properties of cold-cathode glow-discharge tubes.

Cold-cathode diodes and triodes can be divided into two classes. The tubes of the first class are characterized by breakdown voltages ranging from about 120 to about 350V and maintaining voltages of about 90 to 140V. The main physical feature of these tubes is that they are provided with pure-metal cathodes. The tubes of the second class are furnished with oxide-coated photo-sensitive cathodes, and have breakdown voltages ranging from about 75 to 250V and maintaining voltages of 55 to 80V.

The tubes of the first class have stable maintaining voltages and are normally employed as stabilizers and reference-voltage sources. However, their breakdown voltage is not very stable and they are also subject to statistically distributed ignition delays[1]. The tubes are therefore unsuitable for switching applications, where they have to be triggered by pulses, unless they are provided with an adequate source of priming electrons. One of the methods of supplying the required priming electrons is to furnish the tube with a quantity of radium or radioactive tritium. It appears however that the preferred method of priming consists of providing the tube with an additional discharge gap. The auxiliary discharge is kept on permanently and it results in a stable breakdown voltage of the tube. It should be clear that an auxiliary discharge gap makes the tube more complex; thus, in effect, a diode becomes a triode, and a triode becomes a tetrode. It would be wrong, however, to compare the auxiliary gap of a cold-cathode tube with the heater of a vacuum valve, since the gap consumes negligible power.

The priming electrons in the tubes of the second class are provided by the photo-sensitive cathode which has a comparatively low work function. However, the tubes must be provided with a transparent envelope and should be adequately illuminated. The normal ambient illumination is quite sufficient for a satisfactory operation of the tubes. It is necessary, however, to avoid direct sunlight, since this brings down the breakdown voltages; also, the tubes cannot be operated in complete darkness, since their breakdown voltages go up and become unstable (random in magnitude).

The circuits described below are based principally on two tubes with the oxide-coated cathodes and an auxiliary tube having a pure-metal cathode.

Characteristics of the Tubes Employed

The main electrical parameters of the tubes are listed in Table 1. Tube, type XC18, is a subminiature triode having a maximum continuous operating current of 1mA. Tube XC23 is a miniature triode with the maximum continuous current of 7·5mA. In many switching or pulse applications, these current ratings can be exceeded two-fold or five-fold, provided the tubes are given an adequate rest period between successive pulses. Both the tubes are provided with oxide-coated photo-sensitive cathodes and are filled with an argon-neon mixture. Envelopes of the tubes are transparent, so that their glow is clearly visible.

The meaning of most of the parameters in Table 1 should be fairly clear, but a word of explanation may be necessary with regard to the recovery time, t_x, and the dynamic transfer sensitivity, V_p. These parameters are measured in the circuit shown in Fig. 1. For the measurement of V_p the tube is given an anode potential of $V_b = 140$V and a rectangular pulse having a duration of 75μsec is applied to the trigger electrode via a ·001μF capacitor. The amplitude of the pulse is adjusted to a value V_p, such that the trigger-cathode gap of the tube will strike and the anode-cathode or main gap will become ignited. The recovery time, t_x, is measured in the same circuit except that the trigger is connected to earth via a 470kΩ resistor and the anode supply potential is in-

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creased to $V_b = 180V$. The tube is struck and the anode resistor R_a is adjusted so the tube carries the nominal current (1mA or 7·5mA). Negative rectangular pulses are then superimposed on the supply voltage; the amplitude of the pulses is such that the voltage varies from $V_b = 180V$ to $V_{bl} = 50V$. The duration of the pulses is adjusted to a value t_x at which the tube is extinguished. More detailed information on the measurement of the transfer sensitivity and the recovery time can be found in several recently published papers[1,3,10].

The tube, type XC12, is a subminiature diode with a pure-metal cathode. This tube has a stable maintaining voltage and can be used as a reference voltage source or a stabilizer. It is subject however, to statistical ignition delays. Consequently, a tritiated version of the tube (type XC12T) is available, in which the ignition delays are reduced to a negligible value.

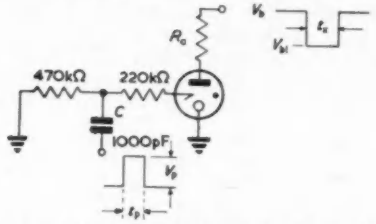


Fig. 1. Test circuit for the investigation of the dynamic characteristics of cold-cathode triodes

The Relaxation Oscillator

The basic circuit of a relaxation oscillator, based on a cold-cathode diode, is shown in Fig. 2. The circuit produces a positive pulse across its cathode resistor R_1 and a negative pulse across R_2. The pulses have an exponential tail with a time-constant $\tau = C(R_1 + R_2)$ and, provided the value of $R_1 + R_2$ is not too low, their combined amplitude is equal to $V_{max} = V_s - V_m$, where V_s is the breakdown potential and V_m is the maintaining voltage of the tube. The interval between two successive pulses is expressed by

$$T = RC \ln \frac{V_b - V_m}{V_b - V_s} \quad \ldots\ldots (1)$$

From equation (1) it is seen that, apart from the time-constant RC, the period of oscillation depends on three voltages: V_b, V_s and V_m. Assuming that V_b is stable, the frequency stability is dependent on V_s and V_m. In the tubes described above, the stability of V_m is quite satisfactory. On the other hand, the stability of V_s in an XC12 or even in an XC12T is inadequate, especially if it is required to operate the oscillator at frequencies of the order

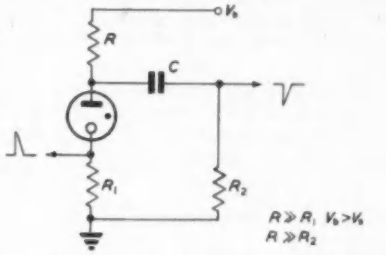


Fig. 2. Relaxation oscillator based on a cold-cathode diode

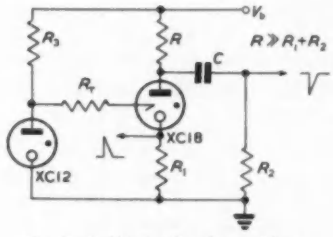


Fig. 3. Stabilized relaxation oscillator

TABLE 1

TUBE TYPES / PARAMETERS	XC18 (SUB-MINIATURE) (HIVAC)	XC23 (MINIATURE) (HIVAC)	XC12 OR XC12T (HIVAC)
Main gap (anode-cathode) breakdown voltage, V_{as}	210V min.	210V min.	104V (nominal)
Nominal main gap maintaining voltage, V_{am}	73V at 1mA (± 5V spread)	70V at 7·5mA	85V at 1mA
Nominal control gap (trigger-cathode) breakdown voltage, V_{ts}	68V (± 6V spread)	68V	
Nominal control gap maintaining voltage, V_{tm}	55V	55V	
Maximum continuous current current I_k	1mA	7·5mA	1mA
Maximum transfer current (d.c.) I_t	30μA	90μA	
Recovery time, t_x	1msec max	1·8msec max	
Dynamic transfer sensitivity, V_p	85V max	85V max	
Dimensions	34 × 10·5mm	45 × 19·1mm	28 × 6·75mm

of a few cycles/min or a few cycles/sec. At higher frequencies (over 50c/s) the stability becomes more satisfactory, since the tubes do not deionize completely between the successive discharges.

The triodes XC18 and XC23 can be used in the oscillators in two ways. The oscillatory circuit can be inserted in the trigger while the anode, with an RC network, acts as a pulse amplifier; a modification of this arrangement can be used as a delay circuit[11]. Alternatively, the trigger can be connected to earth via a high resistance and the oscillatory circuit inserted in the anode. Again, the stability of such oscillators is not satisfactory, especially at the low frequencies. The main reason for the instability is the dependence of V_s on ambient illumination. The situation can be remedied, if a constant priming current is maintained in the trigger-cathode gap of a triode, and its main gap is used as the oscillator. A circuit based on this principle is shown in Fig. 3.

It is seen that the trigger is biased by means of an XC12 or an XC12T. The maintaining potential of these tubes is higher than the trigger maintaining voltage of XC18 or XC23. Since V_m of the XC12 is very stable, a constant priming current can be maintained in the trigger gap of the triodes. This results in a stable breakdown voltage, V_{as}, of the main discharge gap.

In practical oscillator circuits, the resistor R_3 should be such that the XC12 passes about 0·5 to 0·75mA. V_b should be

higher than 150V, since V_{as} of a triode primed by means of an XC12 is about 130 to 150V. If the oscillator employs an XC18, the circuit components should have the following values: $R \geqslant 2{\cdot}7\text{M}\Omega$, $R_1+R_2=6{\cdot}8$ to $15\text{k}\Omega$ and $R_T=1{\cdot}5$ to $0{\cdot}82\text{M}\Omega$. If the circuit is based on an XC23, $R \geqslant 1{\cdot}5\text{M}\Omega$, $R_1+R_2 = 33$ to $3{\cdot}3\text{k}\Omega$ and $R_T = 0{\cdot}82$ to $0{\cdot}47\text{M}\Omega$. The above values of $R_1 + R_2$ ensure that the combined amplitude of the output pulses is approximately equal to $(V_{as} - V_{am})$. R and C can be made very large, but it is important to use capacitors whose leakage is much higher than R. By a suitable choice of CR, it is possible to design satisfactory circuits with the oscillation periods as long as several minutes. On the other hand, CR should not be too low. This is undesirable for the following reason; if the oscillator operates at several kilocycles per second, the residual ionization between successive discharges tends to lower V_{as}; the output pulses are thereby considerably reduced in amplitude.

Apart from using the oscillator of Fig. 3 as a pulse generator, it is possible to modify it into a limit circuit or an amplitude discriminator[12]. If the overall amplitude of the input voltage is higher than V_{as}, the circuit can be

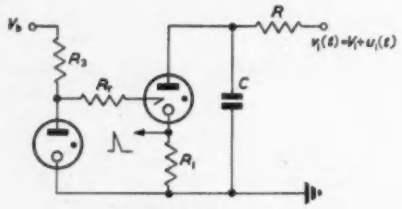


Fig. 4. An upper-level limit circuit for large voltages

in the form shown in Fig. 4. In this circuit, the d.c. component, V_1, of the input signal, $v_1(t)$, should be lower than V_{as}. The triode is therefore not discharging until the transient component, $u_1(t)$, lifts the voltage to V_{as}. This results in the appearance of a positive pulse across R_1. If after reaching V_{as}, the input voltage continues to rise, the circuit will produce further pulses. It should be realized that unless $u_1(t)$ is a comparatively slow waveform, there may be a considerable time lag between the input voltage and the potential appearing across C. If the d.c. component is disregarded, the relationship between $u_1(t)$ and the voltage across C can be expressed by the Duhamel integrals

$$v_c(t) = 1/RC \int_0^t e^{-\tau/RC}\, u_1(t-\tau)\, d\tau \quad \ldots\ldots \quad (2)$$

or

$$v_c(t) = 1/RC\; e^{-t/RC} \int_0^t e^{\tau/RC}\, u_1(\tau) d\tau \quad \ldots\ldots \quad (3)$$

For a step input transient having an amplitude U_1, the voltage across C is

$$v_c(t) = U_1(1 - e^{-t/RC}) \quad \ldots\ldots\ldots\ldots \quad (4)$$

If C was previously biased to U_o, the total voltage is

$$v_c(t) = U_o + U_1(1 - e^{-t/RC}) \quad \ldots\ldots\ldots \quad (5)$$

from which it follows that the tube will fire after a delay

$$t_1 = RC \ln \frac{U_1}{U_1 + U_o - V_{as}} \quad \ldots\ldots\ldots\ldots \quad (6)$$

It should be clear from the above that the arrangement of Fig. 4 can also be used as a delay circuit.

The input signals of a low amplitude can be applied to the modified limit circuit of Fig. 5, in which the capacitor is charged to a voltage $U_o = V_b R_6/(R_6 + R_5)$, such that $U_o < V_{as}$. The transient component appearing across C can be expressed by

$$v_c(t) = \frac{R_5}{[(R_5+R_6)R+R_5R_6]\,C} \int_0^t e^{-\tau/\beta}\, u_1(t-\tau)\, d\tau \quad \ldots\ldots (7)$$

where

$$\beta = \left(R + \frac{R_5R_6}{R_5+R_6}\right) C \quad \ldots\ldots\ldots\ldots \quad (7a)$$

or, if the input is a step having an amplitude U_o,

$$v_c(t) = \frac{U_oR_5}{R_5+R_6}(1 - e^{-t/\beta}) \quad \ldots\ldots\ldots \quad (8)$$

The circuits of Figs. 4 and 5 can be used as upper-level voltage discriminators or as delay circuits. It is also possible to modify the relaxation oscillator of Fig. 3 into a circuit which will produce positive or negative pulses whenever the input voltage falls below a certain value. A lower-level voltage discriminator of this type[12] can be combined with the upper-level discriminator (plus

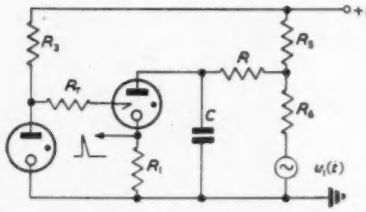


Fig. 5. An upper-level limit circuit for low voltages

a number of auxiliary circuits) to design a simple reversal or limit switch. In the following section, the upper-level discriminator will be used as a stable delay circuit.

Monostable Circuits

The monostable circuits (univibrators) based on cold-cathode tubes are derived from the two basic bistable circuits[1,3,4] shown in Figs. 6 and 7. Operation of the circuit of Fig. 6 is as follows. Initially, V_1 is conducting and V_2 is off; voltage at the anode of V_1 is V_m and the capacitor C is charged to a voltage $(V_b - V_m)$. A suitable pulse applied to the triggers of the tubes via the capacitors C_1 strikes V_2. This results in the anode voltage of V_2 being instantly lowered to V_m; the anode voltage of V_1 is therefore reduced to $(2V_m - V_b)$, which is lower than V_m. Provided the time-constant $T_1 = R_1C$ is sufficiently large, V_1 will be extinguished and C will be gradually charged to a voltage $-(V_b - V_m)$. The waveforms illustrating the operation of the circuit are also shown in Fig. 6.

In the circuit of Fig. 7, V_1 is initially conducting, while V_2 is off. The cathode of V_1 is at a potential $V_k = (V_b - V_m)R_k/(R_k + R_a)$, and the cathode of V_2 is at earth potential. The anodes are at a potential $V_a = V_m + V_k$. The application of a positive pulse to the triggers of the tubes results in the ignition of V_2. The anode voltage is thereby instantly lowered to V_m and, if the capacitance C is sufficiently large, V_1 will be extinguished. The cathode voltage of V_2 gradually rises to V_k, and that of V_1 drops to earth potential. The waveforms generated by the circuit and the time-constants governing them are given in Fig. 7.

The circuit of Fig. 6 can easily be modified into a monostable circuit. The resulting univibrator is shown in Fig. 8. In the stable state, V_2 is conducting while V_1

is off. The anode of V_1 has the full supply voltage V_b, while the anode of V_2 has a potential V_m. The trigger of V_2 is at a certain potential V_t which is dependent on the discharge conditions in the tube and is also a function of R_T and R. If V_1 is ignited by a positive pulse, its anode voltage drops to V_m and that of V_2 falls to $(2V_m - V_b)$. V_2 is thus extinguished and its anode voltage rises exponentially to V_b (see the waveforms of Fig. 8). Voltage of the trigger of V_2 will first drop to a value below V_t, but it will then gradually rise (depending on the time-constant $T = RC$), until it reaches the trigger strike voltage V_{ts}. At this point, V_2 will re-strike and V_1 will be extinguished. After a period depending on the time-constant $T_2 = R_2C_1$, the circuit is ready to accept another triggering pulse. It may be worth mentioning that the timing resistance R can also be connected directly to V_b or to any point on the anode resistor R_2.

It should be clear that, if the circuit of Fig. 8 is based on a pair of XC18 or XC23, its stability will not be very satisfactory, especially when it will be required to generate

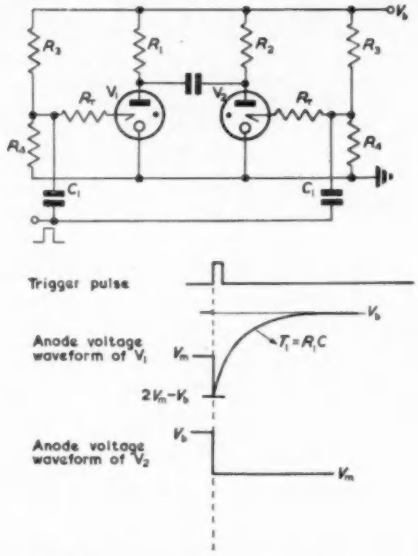


Fig. 6. A bistable pair with the quenching capacitor in the anodes

pulses of long duration (0·1sec to 1min). The situation can be remedied, if the univibrator employs a timing network based on the circuit of Fig. 4. The resulting monostable circuit is then in the form shown in Fig. 9.

The operation of this univibrator is essentially similar to that of Fig. 8, except that the duration of the monostable state is controlled by the limit circuit consisting of V_3 and V_4. The input signal to the RC network is taken from the anode of V_2, so that in the steady state the capacitor C is charged to the maintaining potential of V_2. The timing resistance R can also be connected to a tapping point on the resistor R_2, but the point should be chosen in such a manner that its steady state potential does not exceed the breakdown voltage, V_{as}, of V_3. When V_2 is extinguished, the potential across C rises gradually until it reaches the breakdown voltage of V_3. At this point, V_3 strikes and generates a positive pulse which re-strikes V_2. The cycle is thus completed.

It is possible to describe the operation of the univibrator of Fig. 9 analytically. Assuming that V_1 and V_2 are identical (i.e. $V_{m1} = V_{m2} = V_m$) and that R is connected

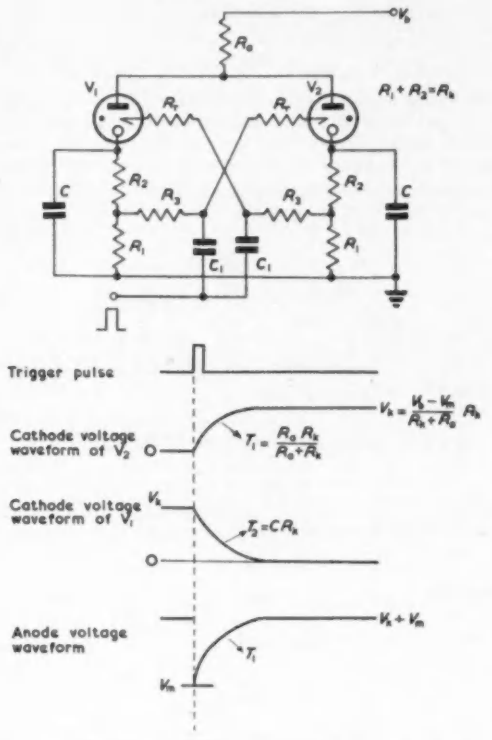
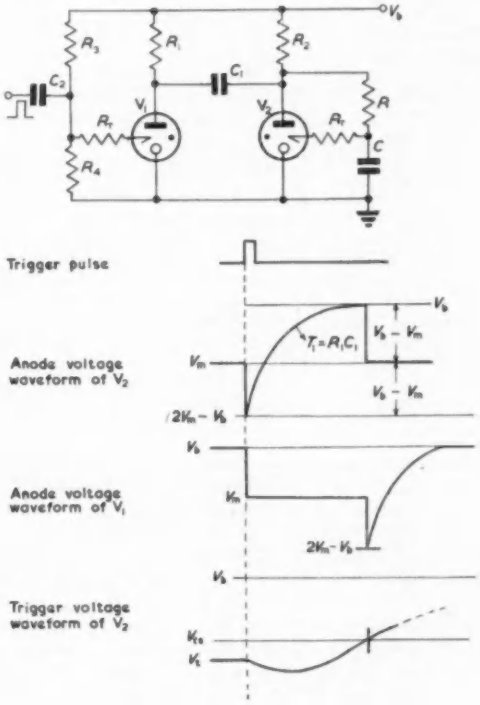


Fig. 7. A bistable pair with quenching capacitors in the cathodes

Fig. 8. Monostable circuit based on the binary pair of Fig. 6



to the anode of V_2, the waveform generated at the anode of V_2 when V_1 is ignited can be expressed by

$$v_a(t) = -(V_b - V_m) + 2(V_b - V_m)[1 - e^{-t/R_1C_1}] \quad \ldots\ldots (9)$$

where the first term represents a negative voltage step and the second term describes the exponentially rising portion of the waveform (see Fig. 8). In equation (9) it is also assumed that $v_a(t)$ is measured with respect to the steady-state component which, in this case, is equal to V_m. Voltage

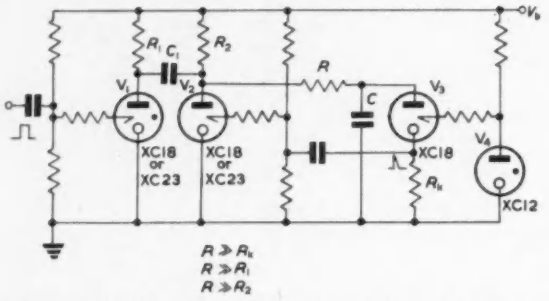


Fig. 9. Stabilized monostable circuit based on the binary pair of Fig. 6

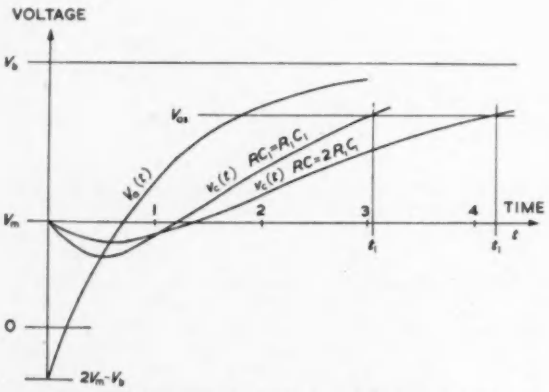


Fig. 10. Voltage waveforms of the univibrator of Fig. 9

across C is given by

$$v_c(t) = 1/RC \int_0^t e^{-\tau/RC}\, v_a(t-\tau)\, d\tau \quad \ldots\ldots (10)$$

or explicitly by

$$v_c(t) = (V_b - V_m)[1 - e^{-t/RC}] + \frac{2(V_b - V_m)}{RC/(R_1C_1) - 1}[e^{-t/R_1C_1} - e^{-t/RC}] \quad \ldots. (11)$$

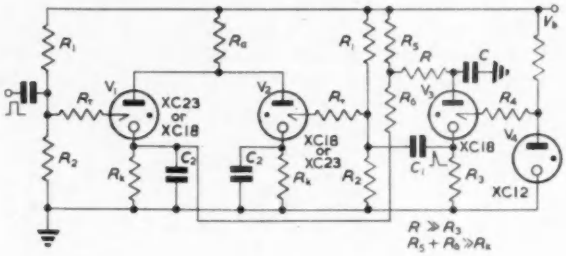
or if $RC = R_1C_1$,

$$v_c(t) = (V_b - V_m)[1 - e^{-t/RC}] - \frac{2(V_b - V_m)}{RC} t\, e^{-t/RC} \quad \ldots (12)$$

The breakdown of V_3 occurs after a time t_1, when $v_c(t_1) = V_{as} - V_m$. Unfortunately it is impossible to evaluate t_1 explicitly, since equation (11) is transcendental. It is comparatively easy, however, to determine t_1 graphically. The procedure is illustrated in Fig. 10, where it is assumed that $V_b = 2{\cdot}5V_m$ and $V_{as} = 2V_m$; Fig. 10 shows $v_c(t)$ for $RC = R_1C_1$ and for $RC = 2R_1C_1$, and also a curve of the anode voltage of V_2.

It can be seen from the above, that the univibrator of Fig. 9 can be designed analytically without much difficulty. In general, all the necessary parameters (V_b, V_m and V_{as}) are either known or can easily be measured. On the other hand, a similar design procedure is not possible with the circuit of Fig. 8 where V_t is not known beforehand. Consequently, the univibrator of Fig. 9 compares favourably with the circuit of Fig. 8 in that its stability is more satisfactory and its design is simpler.

It has been mentioned that it is also possible to modify the circuit of Fig. 7 into a univibrator. This can be done by connecting a timing network to the trigger of one of the triodes. Since such a circuit would have all the disadvantages of the univibrator of Fig. 8, it should be preferable to employ a timing device similar to that of Fig. 4 or 5. The resulting univibrator is shown in Fig. 11. The functioning of the circuit is briefly as follows. In the steady state V_2 is conducting, so that its cathode is at



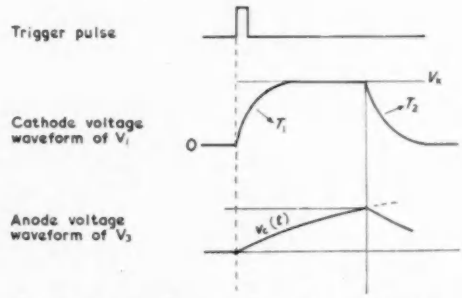


Fig. 11. Stabilized univibrator based on the binary pair of Fig. 7

a voltage $V_k = (V_b - V_m)R_k/(R_k + R_a)$; the cathode of V_1 is at earth potential and the anode of V_3 is biased through R_5 and R_6 to a voltage V_a, such that $V_a < V_{as}$. When V_1 is ignited by an external pulse, V_2 is extinguished. The cathode potential rises exponentially, as expressed by

$$v_k(t) = V_k(1 - e^{-t/T_1}) \quad \ldots\ldots (13)$$

where

$$T_1 = \left(\frac{R_aR_k}{R_k + R_a}\right) C_2 \quad \ldots\ldots (13a)$$

and the anode voltage of V_3 increases by an amount equal to

$$v_c(t) = \frac{R_5}{(R_5 + R_6)\beta} \int_0^t e^{-\tau/\beta}\, v_k(t-\tau)\, d\tau \quad \ldots\ldots (14)$$

where β is given by equation (7(a)). By substituting equation (13) into equation (14), the following expression for $v_c(t)$ is obtained

$$v_c(t) = \frac{R_5V_k}{R_5 + R_6}(1 - e^{-t/\beta}) + \frac{R_5V_k}{(R_5 + R_6)(1 - (\beta/T_1))}[e^{-t/\beta} - e^{-t/T_1}] \quad \ldots. (15)$$

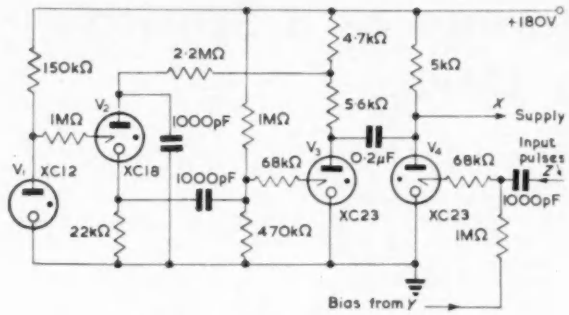


Fig. 12. A practical univibrator circuit

or, if $\beta = T_1$

$$v_c(t) = \frac{R_5 V_k}{R_5 + R_6}(1 - e^{-t/\beta}) + \frac{R_5 V_k}{R_5 + R_6} t\, e^{-t/\beta} \quad \ldots . (16)$$

The tube V_2 strikes after a time t_1, when $v_c(t_1) = V_{as} - V_m$. The positive pulse obtained from the cathode of V_3 re-ignites V_2 and results in the extinction of V_1. The cycle is thus completed. As in the circuit of Fig. 9, the duration of the quasi-stable state, t_1, cannot be evaluated explicity from equations (15) or (16). Again, the equations can be solved graphically without much difficulty.

The univibrators of Figs. 9 and 11 can be used in various switching systems and timing devices. The decision as to which of the univibrators is preferable, will depend on a specific application. Where positive output pulses are required, the circuit of Fig. 11 will be useful. On the other hand, negative pulses having sharp leading edges can be obtained from the circuit of Fig. 9. An example of a practical univibrator is shown in Fig. 12. The circuit is based on two 'large' cold-cathode triodes (type XC23) and it is used to control a number of small tubes (type XC18). The duration of the quasi-stable state in the circuit is about 4msec.

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(To be continued)

Miniature Interdigital Magnetrons

At a recent exhibition, held by Mullard Ltd, of microwave and radar valves, a paper presented by N.N.G. King described a new miniature interdigital magnetron.

Magnetrons are normally considered as large expensive and high powered tubes, but some time ago it was decided to look into the possibilities of producing a valve that was small, lightweight and cheap, while still retaining the magnetron's high efficiency. A particular application might be in radar-sonde balloon equipments where a peak output of a few hundred watts is required and which use, at the moment, disk-seal triodes of much lower efficiency. The magnetron would need to be considerably more efficient than these while still being competitive in size, weight and cost. A target specification, therefore, was set to give a magnetron of greater than 200W peak output at 2850Mc/s with a pulse input of 2kV, ½A.

The design of this valve can be divided into two parts:

(a) The interaction-space, or electronic part.

(b) The resonant system, or r.f. circuit of the valve.

The interaction-space design, and in this is included magnetic field as well as anode and cathode geometries, was based on normal magnetron practice using an eight-segment anode excited in the π-mode, that is with alternate segments π radians out of phase. The requirements of minimum weight and highest efficiency are incompatible, since electronic efficiency rises with magnetic field, while the total valve weight is very largely that of its permanent magnet. Magnet weight was kept down, however, by using the smallest possible pole piece separation (magnet weight varies at the cube of this dimension) and this requirement was borne in mind when choosing the input conditions for the tube, since interaction-space axial length is inversely proportional to the input current, with the voltage and all other parameters constant.

For the anode system something very different to the conventional multi-cavity machined or brazed copper structure was needed, since this is both heavy and expensive to produce. Ideally one would like to avoid the use of any machined components in the tube and so a resonant system was designed which could be fabricated from blanked-out pieces of copper brazed together in a simple jig. The resonant element was a quarter-wavelength shorted lecher line, the required r.f. field pattern round the cathode being obtained by brazing the digits to alternate sides of the lecher line. Due to the singular resonant element this structure has fewer unwanted modes of oscillation than a multi-resonator system, and these modes have frequencies higher than and well separated from that of the desired mode.

There is, of course, one role which this anode structure does not fulfil and that is keeping out the air. However, from the start of this work it was thought that a glass envelope valve had much to recommend it, in ease of construction and cheapness although, since it is convenient to have the magnet pole-pieces outside the glass envelope it does lead to rather large pole-piece spacing and hence a large magnet. This was avoided in the present design by tailoring the envelope to fit the anode structure, and it is made from rectangular glass tube. The output is taken from the resonator by means of a loop and coaxial line of 70Ω impedance. A thin copper shield is placed round the centre part of the envelope to prevent radiation from the anode structure and also to serve as a mounting for the pole-pieces and magnet. The complete packaged valve weighs less than 4oz.

Results for this valve have been very satisfactory and when packaged with the small magnet a power in excess of 200W is achieved at the 2kV, ½A point. With a larger magnet powers of up to 3kW are available. The duty cycle is governed by the anode dissipation limit of 4W. A typical value for the pulling figure is 20Mc/s for a 1·5:1 voltage standing wave ratio.

Work has now been started on an X-band interdigital magnetron along rather similar lines to the one described above and the target being aimed at is a valve suitable for very low-power marine radar applications where only a few kilowatts are needed. The major difference from the S-band valve is the use of a pill-box cavity resonator in place of the lecher system; by this means the unloaded Q is increased, giving better circuit efficiency at a moderate pulling figure. Another difference is in the output system, where a horn is used radiating through the glass envelope directly into X-band waveguide. It is not envisaged that this valve will be of the packaged type, since the magnet needed will be quite large, weighing several pounds, but it is hoped that the glass-envelope magnetron proper should be quite cheap to produce and be a serious competitor to more conventional valves.

The Differential Transformer as a Sensitive Measuring Device

By J. H. Heath*, M.Sc.Eng., A.M.I.E.E.

In the measurement of physical quantities such as strain acceleration etc, it is necessary to convert the mechanical movement into an electrical signal in order that use can be made of electronic amplifiers. This article is the result of a study made into a very sensitive measuring apparatus using a differential transducer as a sensing head and in which phase changes associated with the transducer output voltages have little effect upon the measuring system.

MOST high sensitivity measuring techniques involve the conversion of a mechanical movement (strain, acceleration, etc.) into an electrical signal in order that full use can be made of electronic amplifiers. From time to time various methods have been proposed[1] but among the very many systems that have been tried as transducers, three main methods are at present in general use:

(a) The change in resistance with strain.

(b) The change in inductance with the movement of some part of the transducer or its associated components.

(c) The change in capacitance with movement.

In order to detect the electrical signal produced in any of the above transducers the technique generally used comprises a balanced a.c. bridge network with the transducer as active arm(s) and resistors in the passive arms; by this means stability is obtained. When the system is in its passive state the bridge delivers zero output and in order to achieve this, both the resistive and reactive components must be equal[2] so that the process of balancing the bridge involves two distinct operations. Therefore, if a measuring system is designed in which the phenomenon is to be measured by means of a succession of highly sensitive ranges, each succeeding range must have resistive and reactive balance controls so that the zero of each range may coincide with the maximum of the previous one.

Greater flexibility in the design of transducer measuring circuits would be obtained if the reactive balance could be eliminated (or reduced), and this article analyses a method whereby this has been achieved.

The Differential Transformer[1]

This article is the result of a study made into a very sensitive measuring apparatus using a differential transducer as a sensing head. This inductive transducer consists of a primary winding coupled to two equal secondaries, the voltages in the two secondaries being produced by a movable dust core coupling both primary and secondaries forming a highly stable and sensitive instrument. The three windings can be connected in a variety of configurations, but only two will be examined here.

Consider Fig. 1(a), the primary L_p, R_p is coupled to the two secondaries S_1 and S_2, connected in opposition so that at one position of the dust core d, the output will be zero. If the two secondaries are not exactly equal there will be a residual voltage at E_{out} which cannot be eliminated.

By phase correcting the secondary voltages with r_1 balance conditions can be obtained. The zero output voltage is a function of the core position and as such limits the usefulness of the circuit; by injecting into the transformer secondaries a suitably phase corrected voltage, the electrical zero can be made independent of the core movement[3]. Neglecting the phase correcting potentiometer, the analysis is as follows:

By Kirchoff's Laws Fig. 1(a) yields:

$$\left.\begin{aligned} E\sin\omega t + I_p(R_p + DL_p) - (M_1 + M_2)DI = 0 \\ I_p D(M_2 - M_1) + (2DL + 2R + R_g)I = 0 \end{aligned}\right\} \quad \ldots\ldots (1)$$

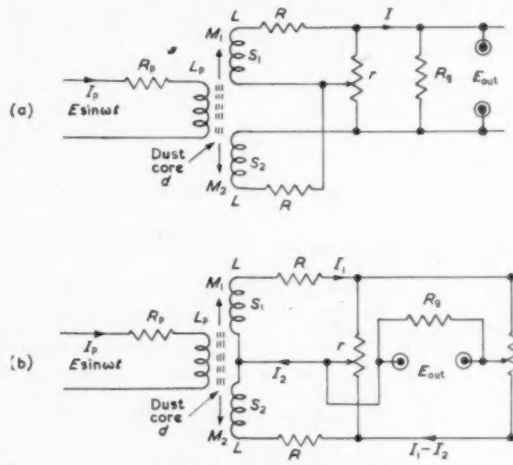

Fig. 1. The inductive transducer

From which,

$$I = \frac{(M_1 - M_2)E\omega\cos\omega t}{(R_p + DL_p)(2DL + 2R + R_g) + D^2(M_2 - M_1)^2} \quad \ldots (2)$$

and E_{out} =

$$\frac{ER_g\omega(M_1 - M_2)\sin(\omega t + \phi)}{\sqrt{\left[(R_p(2R + R_g) - 2\omega^2 LL_p - \omega^2(M_2 - M_1)^2\right)^2 + \omega^2\left(2L_p + L_p(2R + R_g)\right)^2\right]}} \quad \ldots\ldots (3)$$

where

$$\phi = \tan^{-1}\frac{\omega(2LR_p + L_p(2R + R_g))}{R_p(2R + R_g) - 2\omega^2 LL_p + \omega^2(M_1 - M_2)^2} \quad \ldots\ldots (4)$$

when R_g approaches ∞,

$$E_{out} = \frac{E\omega(M_2 - M_1)\sin(\omega t + \phi)}{\sqrt{(R_p^2 + \omega^2 L_p^2)}} \quad \ldots\ldots (5)$$

and

$$\phi = \tan^{-1}(\omega L_p / Rp) \quad \ldots\ldots\ldots\ldots (6)$$

In Fig. 1(b) the two secondaries are connected in series so that in effect the whole secondary is centre-tapped.

* *U.K.A.E.A., formerly Admiralty.*

Again:

$$E \sin \omega t + I_p(R_p + L_pD) - M_1DI_1 - M_2(I_1 - I_2) = 0 \quad \ldots\ldots (7)$$

$$-M_1DI_p + LDI_1 + (R + xR_v)I_1 + I_2R_g = 0 \quad \ldots\ldots (8)$$

$$-M_2DI_p + LD(I_1 - I_2) + (R + (1-x)R_v)(I_1 - I_2) - I_2R_g = 0 \quad \ldots\ldots (9)$$

The phase balance potentiometer r is neglected as its inclusion would only complicate the analysis and would not contribute to the argument.

E_{out} will be $I_2R_g = \dfrac{\Delta I_2 \,.\, R_g}{\Delta}$ ..... (10)

which can be shown to be:

$$\frac{\left[E\omega R_g \cos \omega t \left\{(R + LD)(M_1 - M_2) + R_v(M_1 - x(M_1 + M_2))\right\}\right] \div}{\left[(LD + R + xR_v)\left\{-M_2^2D^2 + (R_p + L_pD)(LD + R + (1-x)R_v + R_g)\right\} + \left\{LD + R + (1-x)R_v\right\}\right.}$$
$$\left.\left\{R_g(L_pD + R_p) + M_1M_2D^2\right\} - D^2(M_1 + M_2)\left\{M_2R_g + M_1(LD + R + R_g + (1-x)R_v)\right\}\right] \quad \ldots (11)$$

If no load is drawn from the bridge $R_g \to \infty$ and

$$E_{out} = \frac{E\omega \cos \omega t \left\{(R + LD)(M_1 - M_2) + R_v(M_1 - x(M_1 + M_2))\right\}}{(R_p + L_pD)(2LD + 2R_v) - D^2(M_1 + M_2)^2} \quad \ldots\ldots (12)$$

Now $(R_p + L_pD)(2LD + 2R + R_v) \gg -D^2(M_1 + M_2)^2$

Thus $E_{out} \simeq$

$$\frac{E\omega \cos \omega t \left\{(R + LD)(M_1 - M_2) + R_v(M_1 - x(M_1 + M_2))\right\}}{(R_p + L_pD)(2LD + 2R + R_v)} \quad \ldots\ldots (13)$$

$$\simeq E\omega \sin \omega t \times \sqrt{\left[\frac{\left\{(M_1 - M_2)R + R_v(M_1(1-x) - xM_2)\right\}^2 + \omega^2L^2(M_1 - M_2)^2}{(R_p^2 + L_p^2\omega^2)([2R + R_v]^2 + 4\omega^2L^2)}\right]} \times e^{j\phi} \quad \ldots\ldots (14)$$

where

$$\phi = (3\pi/2) + \tan^{-1}(\omega L_p/R_p) + \tan^{-1}\frac{2\omega L}{2R + R_v} - \tan^{-1}\frac{\omega L(M_1 - M_2)}{R(M_1 - M_2) + R_v(M_1 - x(M_1 + M_2))} \quad \ldots\ldots (15)$$

when $x = \frac{1}{2}$.

$$E_{out} \simeq \frac{E_\omega(M_2 - M_1)\sin \omega t}{2\sqrt{(R_p^2 + \omega^2L_p^2)}} \,.\, e^{j\phi} \quad \ldots\ldots (16)$$

and

$$\phi = (3\pi/2) + \tan^{-1}(\omega L_p/R_p) \quad \ldots\ldots (17)$$

Thus when the slider on R_v is in the centre position E_{out} can be reduced to zero by moving the core to a point where M_1 equals M_2; if, however, this is undesirable, x can be moved a distance such that from equation (13):

$$x \simeq \frac{1}{(M_1 + M_2)R_v}\left\{R(M_1 - M_2) + M_1R_v \pm \sqrt{[M_1RR_v(M_2 - M_1)]}\right\} \quad \ldots\ldots (18)$$

and ϕ will be given by equation (15) when x is substituted according to equation (18). Thus E_{out} can always be reduced to zero by an adjustment to the voltage potentiometer R_v combined with the phase control. r.

Use of Differential Transformer for the Measurement of Small Increments in Displacement

When large displacements have to be measured to a high degree of accuracy as in the case of investigations into the creep testing of metals, it is necessary to divide the total movement into a succession of highly sensitive ranges: when the differential transformer dust core has moved a distance equivalent to the first range, the output voltage must be reduced to zero at the commencement of the second range.

The sensitivity obtained in each range is only limited by the amplification available, the heating limits of the differential transformer and the stability of the measuring circuits. Equation (5) shows that the series opposition method is twice as sensitive as the series connexion (equation (16)).

Most of the early measuring techniques using differential transformers are based upon the series opposition method but the analysis in this article shows that E_{out} is only zero for one position of the dust core showing that it is not easy to design a measuring system with a succession of ranges, although a method is shown by Heath[3] whereby a suitably connected anti-phase voltage is injected into the differential transformer secondary at the commencement of each range.

The series connexion has been shown as suitable for the sub-division of the transducer linear range into a succession of highly sensitive sections, the analysis has proved that a balance can always be achieved at any part of the range. Equations (14), (15) and (18) show that the zero of each range must be achieved by both a voltage and phase adjustment; the equations also show that balance conditions will be true for only one set of positions of the dust core. This severely restricts the practical use of the transducer as it means that mechanically the core must be capable of being moved to the zero position of the first range. In effect, apart from its ability to obtain a balance for any position of the dust core, the series connexion in the particular application discussed in this article is restricted just as much as the series opposition connexion in as much as the dust core must be movable in the initial setting up of any apparatus in which the transducer is used.

The Elimination of Phase Shift

Consider equations (14) and (15) when R_v approaches ∞:

$$E_{out} = \frac{E\omega(M_1(1-x) - xM_2)\sin \omega t \,.\, e^{j\phi}}{\sqrt{(R_p^2 + \omega^2L_p^2)}} \quad \ldots\ldots (19)$$

where

$$\phi = 3\pi/2 + \tan^{-1}(\omega L_p/R_p) \quad \ldots\ldots (20)$$

and x the movement of the slider on R_v for a balance when the core is moved:

$$\frac{M_1}{M_1 + M_2} \quad \ldots\ldots (21)$$

Let M be the mutual inductance of each half of the transducer when the core is in the electrical centre, and let the core be moved a distance y from the centre. It is assumed that the mutual inductance changes linearly with the core movement.

$$E_{out} = \frac{E\omega M(1 + y - 2x)\sin \omega t \,.\, e^{j\phi}}{\sqrt{R_p^2 + \omega tL_p^2}} \quad \ldots\ldots (22)$$

and hence to reduce E_{out} to zero on the slider on R_v must be moved a distance:

$$x = \frac{1 + y}{2} \quad \ldots\ldots (23)$$

Thus the output voltage is no longer phase conscious with the core movement and once a given set of ranges have been decided upon, these are no longer dependent upon the core position.

The effect of making $R_v \rightarrow \infty$ can be achieved by operating the transducer into a valve measuring circuit as shown in Fig. 2.

Equations (19) and (20) show that neither the secondary self inductance L nor the resistance R influence the output voltage; in fact, provided the mutual inductance M_1 and M_2 change linearly with movement of the core, they need not have the same intrinsic value and E_{out} will always change linearly with core movement. Another important result of the analysis is that the transducer winding specification can be relaxed considerably: there is now no need to closely

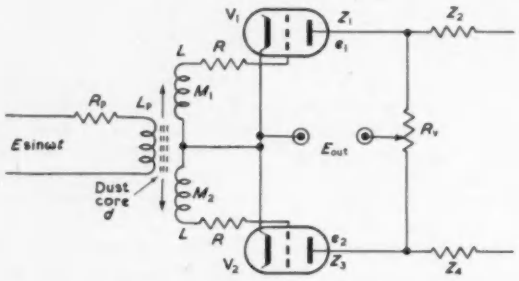

Fig. 2. Operation of transducer into valve measuring circuit

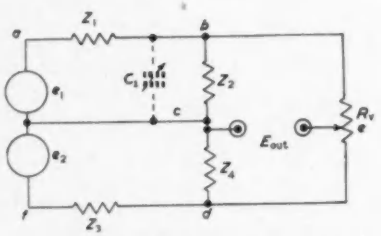

Fig. 3. Circuit derived from Fig. 2

match the two halves of the secondary, to take a specific example they could be wound in different gauges of wire and E_{out} would still be linear with core movement.

Vectorial Analysis of Measuring Circuit

Consider Fig. 3 which shows the circuit derived from Fig. 2 where e_1 and e_2 are the transducer secondary voltages after amplification by V_1 and V_2. Z_1 and Z_3 are anode impedances of V_1 and V_2 and Z_2 and Z_4 the anode load impedances.

If e_1 and e_2 have a relative phase shift $\theta°$ and Z_1-Z_4 are complex, the vector diagram will be as shown in Fig. 4(a). It will be seen that ce, the output voltage, cannot be reduced to zero unless there is both a voltage and phase adjustment in the circuit. If vector cb be corrected by a capacitor C_1 and e moved along bd, E_{out} can be reduced to zero as shown in Fig. 4(b). If e_1 and e_2 change linearly with core movement and θ remains unaltered, the relative displacement of bd remains unchanged. Consequently E_{out} is either in or out of phase travelling linearly with core movement along vector bd, and its value depends upon the position of e on R_v and at one position will be zero.

Thus for all positions of the dust core within the transducer range a balance can be achieved by adjustment to R_v only.

The effect of the impedance changing network V_1 and V_2 is to make R_v in Fig. 1(b) much greater than any other parameter in the circuit, and for all practical purposes the desired conditions in equations (19) and (20) have been reached. The vector diagram also shows that E_{out} is directly proportional to the change in e_1 and e_2, i.e. the circuit output is linear with core movement. In practice there is no relative phase shift between e_1 and e_2 as no current is drawn from the transducer.

Now R_v in Fig. 2 will have distributed inductance and capacitance so that as the slider is moved there will not be a purely resistive change in the network. The result is that vector ce in Fig. 4(a) cannot move along the straight line bd but follows a shallow hyperbola[2]; an additional amount of capacitance will therefore be required in C_1 to

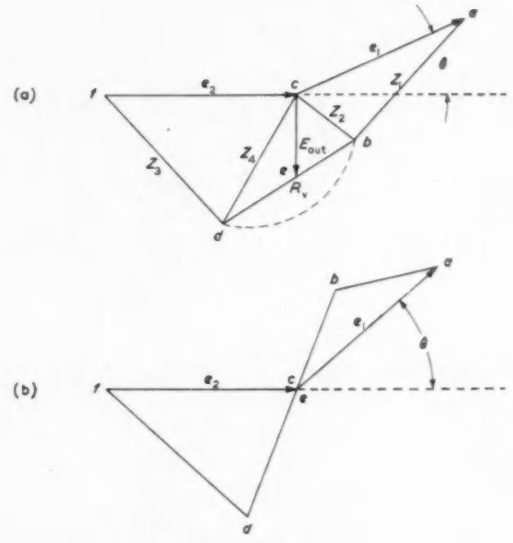

Fig. 4. Vector analysis of Fig. 3

correct the slight change in vector configuration when e is moved. This means that the system is balanced for one position of the core and if it is moved from this position the point c moves along bd; when e is moved along R_v to reduce ce to zero again a small correction must be made to C_1. It should be noted that this capacitance change is due purely to the imperfection in the potentiometer R_v and, provided that the transducer output is linear with core movement, for a given core movement anywhere within the transducer linear range, the change in C_1 will always be the same.

This property leads to an important application of the circuit: once a given set of core movements has been decided upon (by a series of positions of e on R_v), it will only be necessary to rebalance the first range, in order to commence at any part in the transducer linear range, the other ranges will always be balanced as the phase change in each is due only to the distributed reactance of R_v.

Practical Application

V_1 and V_2 in Fig. 2 are in effect a differential amplifier stage subtracting the amplified signals from the two halves of the transducer secondary. Fig. 5 shows a practical circuit developed from Fig. 2.

The transducer B has both a centre-tapped primary and secondary, the primary being fed from a push-pull oscillator A. The output voltages M_1 and M_2 are fed into the measuring stages V_3 and V_4 via cathode coupled matching stages V_1 and V_2. At the anodes of V_3 and V_4 the amplified signals M_1 and M_2 are subtracted and E_{out} obtained from the switching network S_1, S_2 and S_3. On range 1 with the core of the transducer B at some point in its linear range E_{out} is reduced to zero by means of equal ganged potentiometers VR_1 and the differential capacitor C_1. When the limit of the first range is reached S_1, S_2 and S_3 are switched to the second range which is balanced by VR_2 and C_2. As many ranges as desired can be accommodated by increasing the number of switch points S_1-S_2. It will be recalled that the capacitor C_1 corrects the phase change due to the alteration in distributed reactance when the potentiometers VR_2, VR_3, etc., are moved.

Once the system has been set up, the ranges set by VR_2, VR_3, etc., remain approximately fixed for any given starting point in the transducer linear range, thus if it is desired to commence the ranges at some other point the first range is balanced by VR_1 and C_1, the remaining ranges being automatically balanced. It will be seen that the change required in C_1 to rebalance range 1 is due to reactance alterations in the network when VR_1 is moved. A coarse/fine ratio control for balancing can be achieved by a suitable choice for VR_1 and the range potentiometers VR_2, VR_3, etc. In a specific application of the system to the measurement of the co-efficient of linear expansion of materials, a differential transformer with a linear range of 0·1in was used in which the maximum sensitivity on each of the successive ranges was 5×10^{-4}in. Therefore, any change taking place as the 2in specimen was heated could be automatically recorded to 5μin; in practice a range sensitivity of 5×10^{-3}in was found adequate.

Limitations

Although the analysis shows that a given set of ranges once set up will remain balanced for any part of the transducer linear range, in practice it has been found that if an attempt is made to rebalance the first range outside the limits of ± 50 per cent of the expansion covered by all the ranges, the zero for each successive range is no longer balanced, this has been shown to be due to:

(a) Eddy currents and hysteresis losses in the dust core and windings throwing a small variable impedance across the transducer thus creating a relative phase shift between the two secondary voltages (equation (15)).

(b) The reactive distribution along the balance potentiometer being hyperbolic.

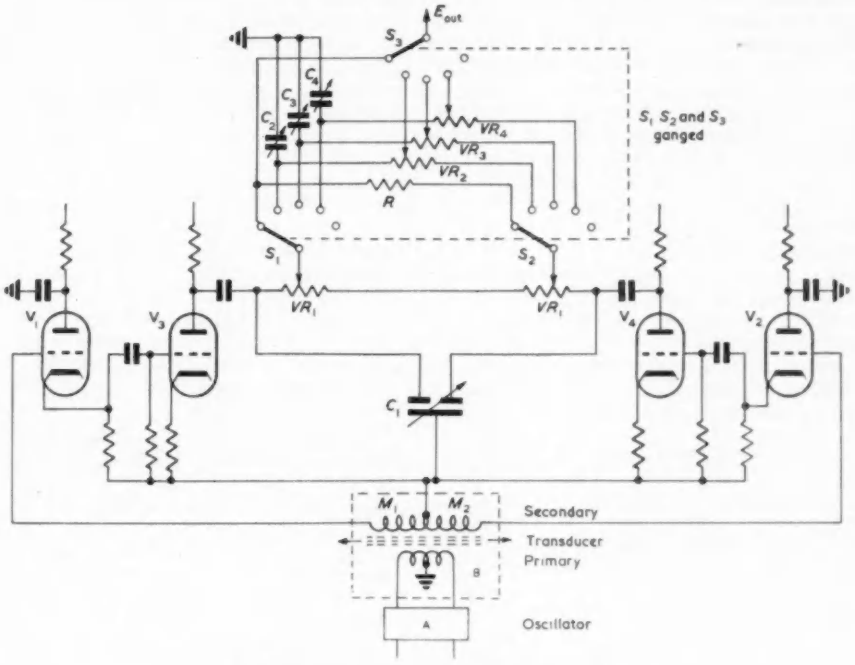

Fig. 5. A practical circuit developed from Fig. 2

Conclusions

This article is a condensed account of part of a programme of work undertaken in the application of electronic measurement technique to the study of behaviour of materials at high temperatures. The work shows that a very sensitive measuring technique has been designed in which phase changes associated with the transducer output voltages have little effect upon the measuring system.

The measuring system has been applied in this instance to an inductance strain gauge, but could equally be applied to many other forms of transducer.

Acknowledgment

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Control Apparatus for a Serial Drum Memory

By D. S. Kamat*, M.Sc.

This article describes an apparatus that has been developed and used successfully for obtaining design data for a faster track switching device for a serial drum memory. It gives circuit and performance details of the gates, triggers, switches and other components that have been developed. The apparatus is intended for further use for study of other computer functions.

IN an electronic digital computer[1,2] with a magnetic drum as its principal fast memory, and working in a serial mode the total memory storage capacity is shared between a number of tracks; where each track corresponds to one of the record-reproduce heads. The selection of a track or (record-reproduce head) is done in many cases by means of a group of electro-mechanical relays. It is felt that at least a few types of faster switching devices may be tried other than the usual relay tree track selection device. To conduct these experiments in particular and to study other design problems connected with serial memory devices in general a control apparatus was constructed.

This apparatus has three functions to perform, namely to generate coded information consisting of 32 bit word, to route this information to a given location on a memory track (or to extract information from a location and store it in a register) and to generate fast switching impulses that are to be used both in selection of a required track and in performing either of the record-reproduce functions.

A Synchronous Device and the Process of Transfer of Information

The apparatus is shown in a block schematic diagram in Fig. 1. The unit on the right-hand side of this diagram makes it possible to shift a word of 32 bits to and from a memory location whenever commanded. The unit has a shift register, a five-stage binary counter and an asynchronous to synchronous pulsing device that may start the shifting operation. Fig. 2 shows the circuit of this unit excluding the shift counter and the shift register. Suppose that there is a number already stored in the register and it is to be shifted by n places ($n < 32$). This n is set in the shift counter (with the help of manual switches) and whenever the switch S_1 is thrown over from 1 to 2 it unsets trigger T_1 (valve V_2) opens gates G_1 (valve V_3) and G_2 (valve V_5). Both these gates receive clock impulses (i.e. 32 selected clock pulses), the former directly and the latter delayed by a few microseconds via a delay trigger (valve V_7). The output of G_2 resets trigger T_1 to its normal state. As a result the gate G_1 allows only a single pulse to pass through which resets trigger T_2 (valve V_8). The gate G_0 (valve V_{11}) allows the 32 input pulses to pass which, after being amplified, simultaneously act as shift impulses for the shift register and input pulses to the shift counter. The shift counter, after completing a count of 32, sets trigger T_2 which in turn closes gate G_0, thus terminating both shifting and counting operations.

Pulse inputs ranging from a pulse repetition rate of 10kc/s to 100kc/s, as well as a memory drum giving clock pulses at 34·08kc/s were tried successfully in testing this operation.

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Selection of a Track and Associated Functions

A multi-position switch[3,4], using crystal rectifiers in association with a track address register, is used for selection of record-reproduce heads. Initially the multi-position switch is to select any one of the 16 positions, each corresponding to one of the 16 configurations possible in an address register with four binary stages. Fig. 3 is the circuit diagram of the multi-position switch. The lower row in the figure is the trigger assembly representing the address of the track. Both anodes of each of the triggers are connected separately to inputs of cathode-follower valves (V_{12} to V_{15}) the output levels of which control the switching action corresponding to the actual state of the triggers. Corresponding to the two levels (70V and 165V) on the trigger anodes, the cathode-follower cathodes rise to 85 and 185V respectively. These voltages after passing through a dividing network are fed to the grids of the switching valves (V_{16} to V_{30}). The switching valves either conduct fully or remain cut off.

It can be seen from the circuit diagram that a selected position (or terminal) has four 'and' gating diodes. The anodes of these diodes are raised to +h.t. (250V) via the 22kΩ resistors because the corresponding sections of the switching valves are not conducting, while the cathodes of these four gating diodes are each held to a voltage existing at the anodes of the rest of the (conducting) valves through the back resistances of 7 other diodes. The latter voltage level, what may be termed as the reference level, is adjustable by suitably fixing the screen voltage of the switching valves. In the case shown this reference level is at 70V, while the selected terminal is at 100V. Fig. 7(e) is an oscillogram of the transient impulse obtained at a switch position.

Later this pulse, on a selected switch position, is fed into a current switching device which gates either a waveform to be recorded or 32 clock pulses depending upon whether the record or reproduce function is to be performed.

Selection of Word Location on a Track[5,6]

On each track of the memory drum there may be more than one word location, the actual number depending upon the drum diameter and the digit packing density on the surface. In the present case the drum has 16 word locations per track. The identity of each of these 16 of words is established:

(1) By making the spacing or free interval between the first and the last word different and larger than that between the rest.

(2) By recourse to a synchronization device.

(3) By sensing the coincidence between the word address and the word counter when it occurs.

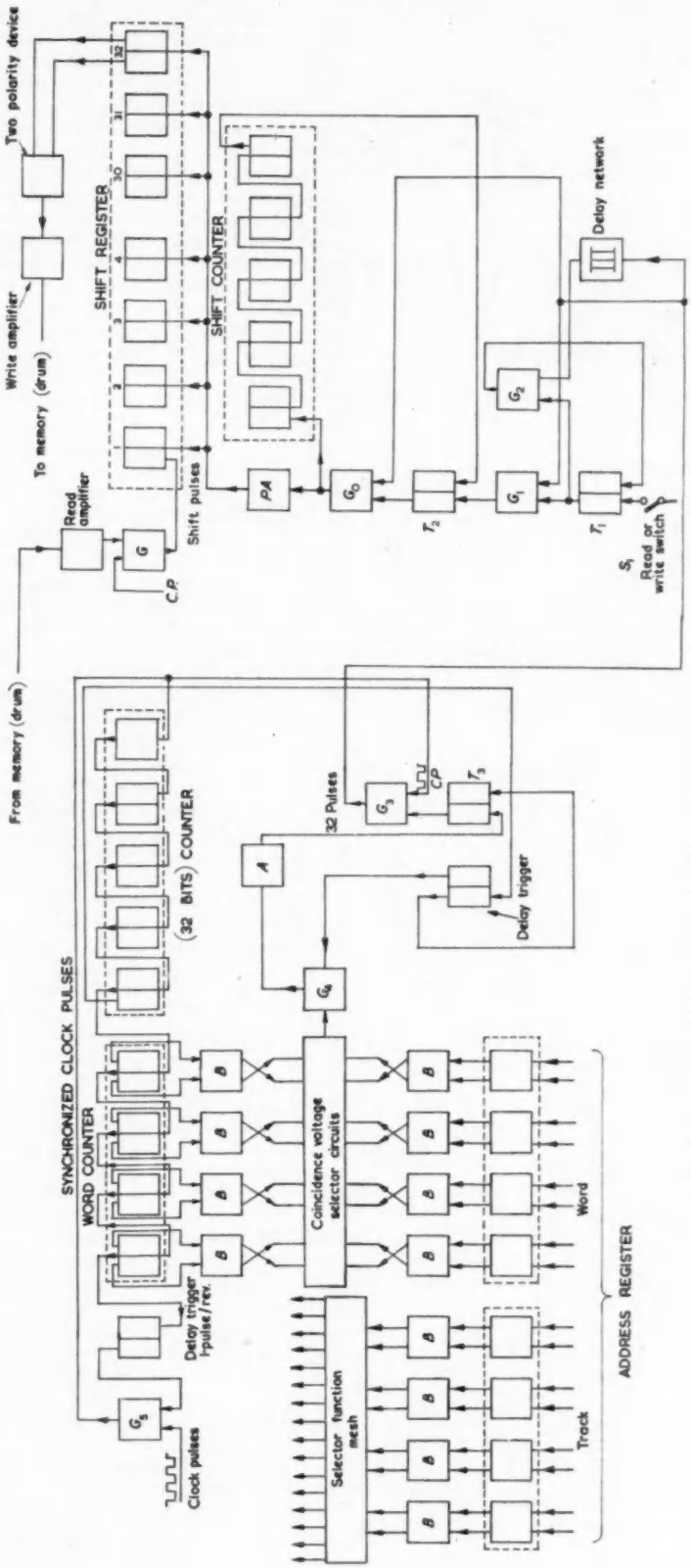


Fig. 1. Schematic of control for selection of location (address) and storing of operand in magnetic drum calculator

The pick-up head for clock pulses generates 16 groups of 32 pulses and these are spaced as stated above. These clock pulses are fed into a nine stage binary counter (see top left-hand portion in Fig. 1) and the counter generates a single pulse per drum revolution. A monostable multivibrator is turned 'on' by this pulse for a duration much longer than the spacing (or its equivalent in time) between all words except that between the last and the first. This multivibrator controls gate G_5 and as a consequence of the above it shuts off a portion of the pulses that normally get past. In a few revolutions the shutting off of output pulses from G_5 coincides with the end of each drum revolution, a state corresponding to complete synchronism.

The selection of 32 clock pulses corresponding to the required address location is done with the help of a scheme (as shown in Fig. 1) consisting of a coincidence voltage selector, trigger T_3 and gates G_4 and G_3. Each of the end of the word pulses coming from the 32 bits counter triggers a delay trigger which in turn generates a pulse that could be shaped to give a pulse coincident with input pulses and also another one delayed by about 100μsec. One of the latter 16 pulses is allowed through gate G_4 wherever the correct coincidence voltage level occurs. This pulse turns 'off' trigger T_3 which opens gate G_3 and thus allows input clock pulses to pass through. However, the next end of the word pulse turns the trigger T_3 'on' and thus closes gate G_3. So a maximum of 32 clock pulses pass through gate G_3 per drum revolution and are always coincident with the selected location as shown on an address register.

Triggers and Gates

Fig. 4(a) shows the trigger circuit[7,8] which stores binary bits '0' or '1'. A row of triggers, as shown in Fig. 3, when connected via gating diodes[1] (also shown in the same figure) constitutes a register for storing an address, a number or an instruction, all three generally being referred to as a 'word'. The d.c. voltage levels at the various electrodes are also shown. To turn the trigger in either of its stable states pulsed inputs at the grids of V_{1a} and V_{1b} are required. V_{1a} and V_{1b} are normally conducting valves. When anode current—anode voltage characteristics for 6SN7 valves for voltages in the range 30 to 40V are studied it is found that they have a constant slope. Thus for the analysis of the behaviour of the triode pair V_{2a}

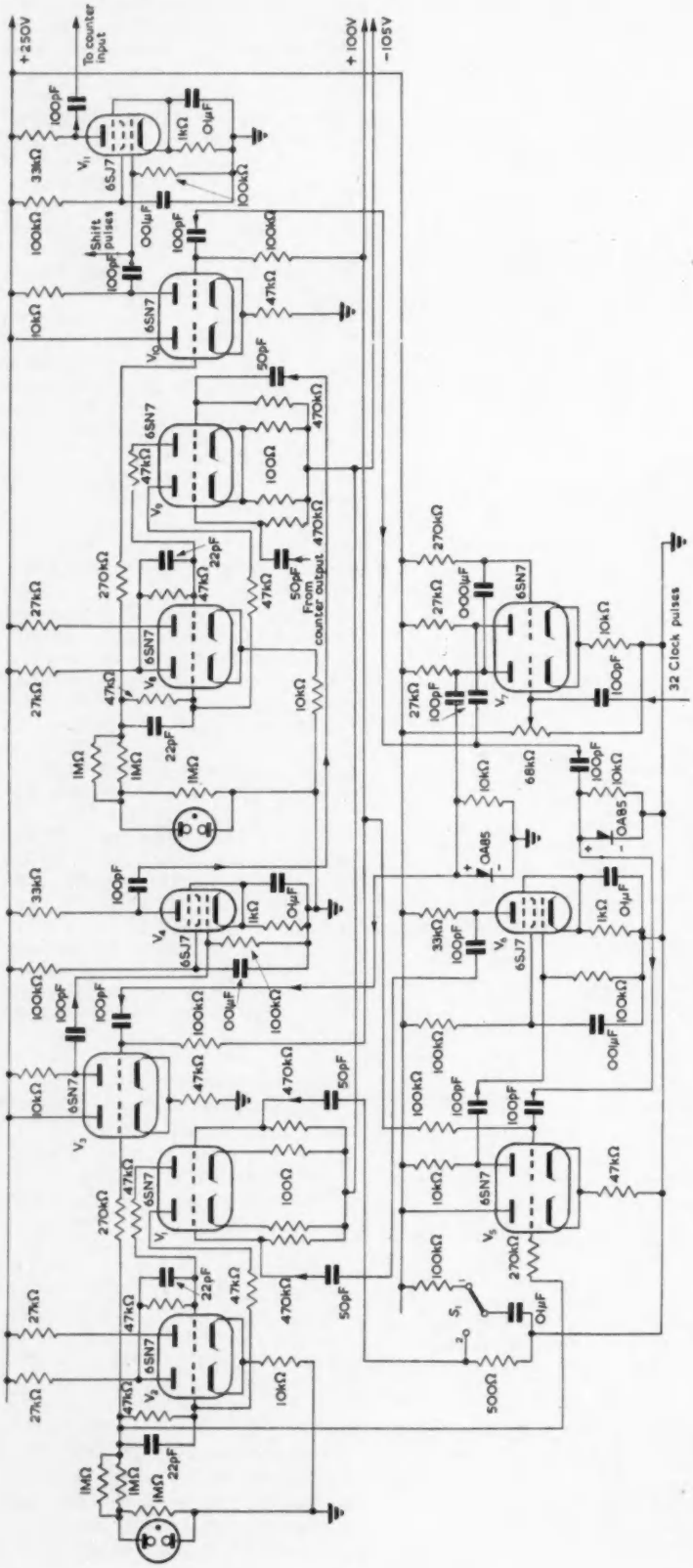


Fig. 2. Single pulse generating unit and control for shift operation

and V_{2b} both V_{1a} and V_{1b} could safely be regarded as constant resistances of equal value. The cathode degeneration introduced by a cathode resistance of 100Ω also helps in equalizing the transconductance of the valves for both the sections namely V_{1a} and V_{1b}. A simplified version of the circuit will then reduce to the one shown in Fig. 4(b). This approximates to the usual trigger circuits discussed[8] with the difference that the common cathode is grounded through a resistance that is not by-passed. This has an effect of greatly increasing the valve resistance and thus making each valve circuit effectively a constant current device. Fig. 5 shows a counter trigger circuit.

There is only one type of gate circuit that is used. In all places it is used in association with the d.c. voltage levels on a trigger anode. Whenever the relevant anode of a trigger (Fig. 6) or delay trigger is high (165V) the common cathode of the gate valve is raised to this voltage and hence the gate remains closed. When the grid of V_a is at 70V (corresponding to the altered state of the trigger) the common cathode can drop from 100V to this voltage whenever the grid of V_b is pulsed negatively, and then the output occurs.

The coincidence sensing gate for selection of word location on a chosen track is shown in Fig. 6(b). The two voltages that are summed at the grids of V_1 to V_4 are from opposite anodes of triggers representing bits of equal significance in the word counter and the word register. The common cathode of the summing valves will have a voltage of 105V whenever coincidence occurs, i.e. when the corresponding digital places in the counter and address register are of equal significance. At other times the cathode would be at 165V. Thus when the grid of V_5 is pulsed the cathode can drop from +135 to +105V only when coincidence occurs, at other times the gate will be held closed.

Performance Characteristics

The equipment was constructed with components and valve types that were readily available. It was desired that the switching speeds of various triggers and circuits should be such as to facilitate a wider degree of freedom for the study of computer functions such as auxiliary memory devices, input/output conversion, as well as a memory drum track switching device with pulse repetition rates up to 100kc/s.

Simulation of variation in computing speed is obtained by substituting in place of the magnetic drum a laboratory

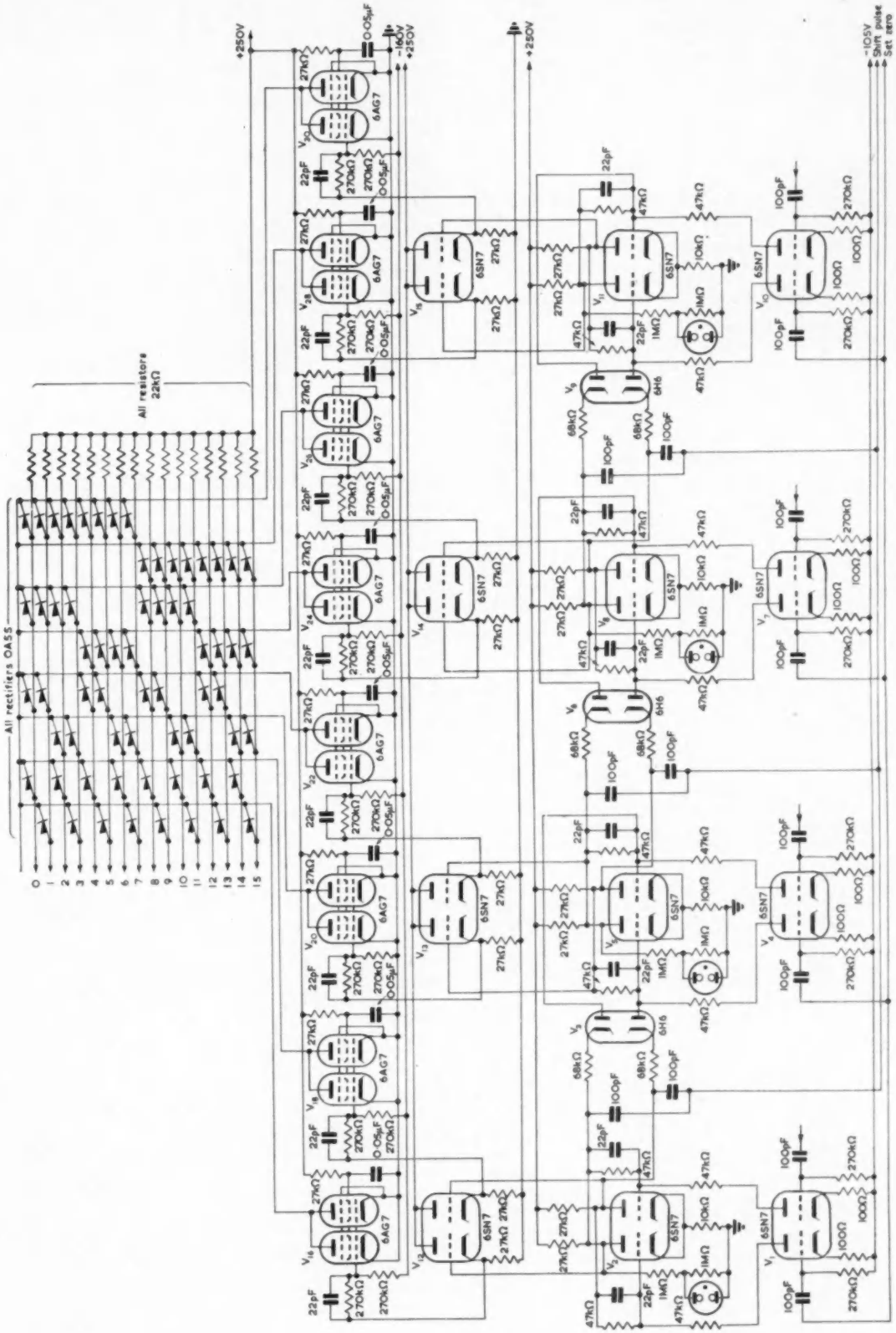
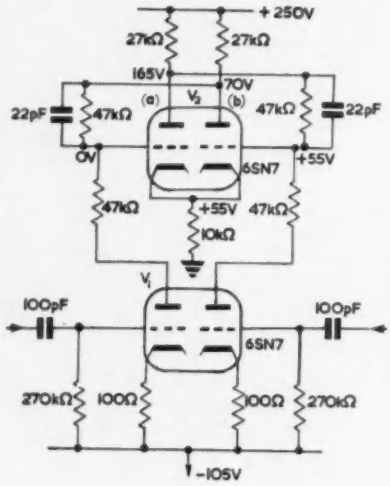


Fig. 3. Control circuit for track selection



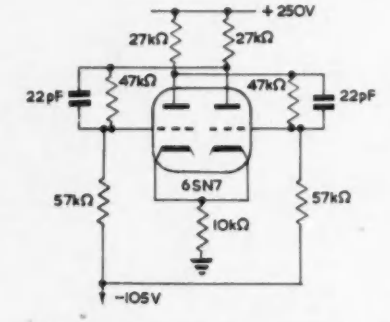


Fig. 4. (a) Trigger circuit; (b) Equivalent for the trigger circuit

pulse generator having a frequency range from 6kc/s to 150kc/s. When such a pulse source is used the synchronization circuit gives a burst of 512 pulses. The clock pulses corresponding to a drum location then obtained will not be 32 but less (as there is no gap between words). Fig. 7(a), (b), (c) shows such selected pulses at repetition rates of 100kc/s and 10kc/s and also the 32 selected pulses when a memory drum with clock pulse repetition rate of 34·08kc/s was used.

The response curves for the track selection device were

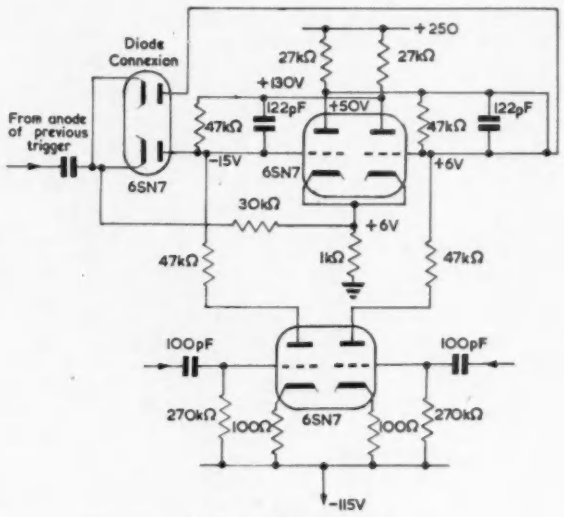
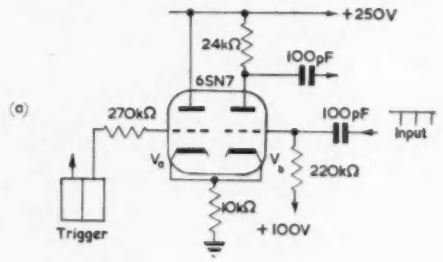


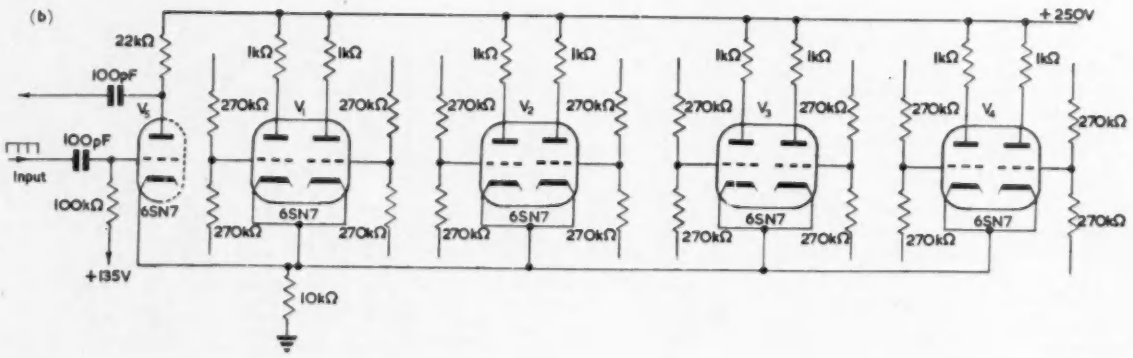
Fig. 5. Counter trigger circuit

obtained when the triggers of the track address register were set and reset within 2μsec intervals at 5kc/s.

The counter and register trigger and the gate circuits operate satisfactorily at pulse repetition rates and in association with other equipment in the manner stated above. Valves in the counter and register trigger cells each dissipate about 15 per cent of their rated maximum anode dissipation. Filament supply is maintained mostly at 6·3V a.c. although no special a.c. stabilizing methods are used. The 250V d.c. supply is made available through smaller series stabilized power units, each giving about 200mA. The total d.c. at 250V required for all the units as shown in Fig. 1 (excluding the record/reproduce functions) is

Fig. 6. (a) A gate circuit; (b) Coincidence sensing device





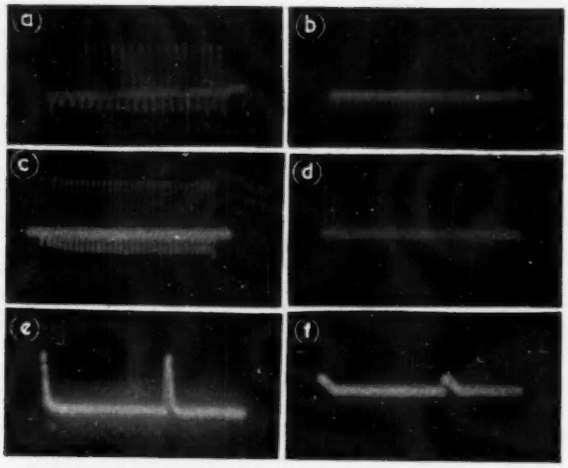


Fig. 7. Oscillograms obtained when using laboratory pulse generator

(a) 100kc/s pulses, synchronized and selected
(b) 10kc/s pulses, synchronized and selected
(c) 32 clock pulses form the memory drum (34·08kc/s) synchronized and selected
(d) 16 end of word pulses from the memory drum
(e) Transient response of the track selector switch. Output amplitude 30V, pulse width at bottom 2μsec
(f) Same switch position as in Fig. 7(e) but when not selected

nearly 1A. The valve types used are 6SN7, 6H6, 6AG7 and 6SJ7; out of these 6SN7's constitute about 80 per cent of the total. The failure among the germanium diodes used in the selector switch was relatively large (about 40 per cent), their back resistance in such cases varying between a few thousand ohms to about 100kΩ. These were replaced by newer types.

Acknowledgments

The author wishes to thank his many colleagues in the Electronics Laboratory and the Development Workshop of the Institute for their help in the work and in particular Mr. Bijan Mukherji and Mr. K. M. Patnaik for help in construction of this apparatus.

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The Effect of a Magnetic Field on Point-Contact Transistors

By K. K. Bose*

When a magnetic field is applied to a point-contact transistor at right-angles to the plane of the emitter and collector, interesting observations have been made of the alterations of all the characteristics of the transistor, both static and dynamic. The changes which take place in the operational characteristics of the transistor are positive or negative with respect to the normal values, according to the polarity of the applied field. Brown[1] first noticed that the frequency response of a point-contact transistor improved when it was magnetically biased with the proper polarity. In the present article not only the frequency response, but the changes in the output characteristic and amplification characteristic of the transistor due to a magnetic field, as determined experimentally, have been presented and an attempt has been made to give a suitable explanation for the peculiar behaviour.

THE action of the point-contact transistor is primarily determined by the nature of the current flowing from the emitter. When the emitter and the collector are placed in close proximity, a large part of the 'holes' injected by the emitter in the n-type transistor will flow to the collector and into the collector circuit, on account of the electric-field set up by the collector current. The carriers are drawn to the collector and add to the collector current. As mentioned later, this addition is not algebraic. The injected holes which concentrate around the collector point modify the barrier space-charge below the collector in such a way that the change in collector current is more than the change in the emitter current to which the former is due; or, in other words $\Delta I_c > \Delta I_e$ and α of the point contact transistor is greater than unity. The value of 'alpha' (α) depends not only on the spacing between the emitter and the collector, but also on the forming process etc., by which a *p*-layer is formed below the collector in the n-type germanium. The frequency response of the transistor is, however, primarily dependent on the geometrical spacing between the emitter and the collector, other things, e.g., temperature, mobility etc., remaining constant.

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The nature of the collector is normally such as to provide a high resistance barrier to the flow of electrons from the metal to the semiconductor (being reversely biased), but there is little impediment to the flow of holes. In addition, the hole-current causes an enhanced flow of electrons from the collector to the semiconductor.

If I_c be the collector current, the field (F) produced at a distance r from the collector:

$$F = \rho I_c / 2\pi r^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where ρ = resistivity of the germanium (ohm-cm).
The drift velocity of the holes flowing from the emitter to the collector is:

$$v = \mu_h F \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where μ_h is the hole-mobility (cm²/V.sec).

The time taken by a hole to reach the collector vicinity from the emitter source, i.e., the transit time (T),

$$T = \int dr/(\mu_h \cdot F) = 2\pi/\mu_h \rho I_c \int_0^s r^2\, dr$$

or,

$$T = \frac{2\pi S^3}{3\mu_h I_c \rho} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where S is the separation between the emitter-contact and collector-contact.

Frequency Response

The transit time has an approximately inverse relationship to the frequency response. Thus the frequency response would be expected to vary inversely as the cube of the point spacing if other conditions were maintained constant. In practice the transit time is of the order of 10^{-6}sec. It is obvious that as the frequency is increased there will be an increased phase-shift as well as reduction of current-amplification (α), since the hole-current arriving at the collector from the emitter will be dispersed in phase.

Now it suggests itself that if a magnetic field is applied at right-angles to the plane of the emitter and the collector, the path of the hole current will be diverted from the original one, i.e., the effective value of the spacing S between the emitter and the collector will be changed. This will result in a change in the transit time T, thus altering the frequency response of the transistor.

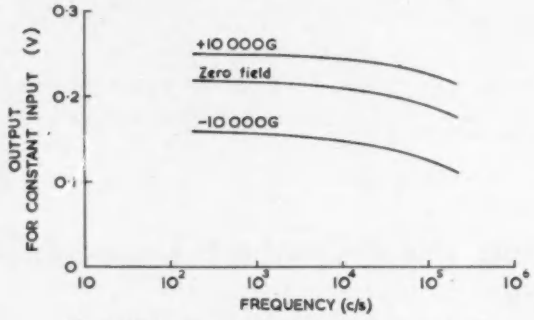

Fig. 1. Effect of magnetic field on frequency response

In Fig. 1 the effect of the magnetic bias of about 10kG is shown. The transistor used was the Western Electric, type WE-2A.

Depending on the polarity, the magnetic field tends, (1) either to compress the hole-current towards the surface reducing the average path length and the transit time, resulting in less phase dispersion, or (2) to force the hole-current to travel over widely varying paths. The hole-current is diverted from the surface downwards and forced to flow deep through the body of the germanium. This is possible, since Shockley and Shive[2] have shown independently by their famous slab type and wedge type germanium experiments that the flow of the hole-current is not confined to the contact surface only. The holes may flow through the surface layer as well as through the body of the semiconductor, as shown in Fig. 2.

The amount of deflexion of the path of the hole current will depend on the strength of the magnetic field, and the direction of the deflexion on the polarity.

Another thing to be noticed in Fig. 1, is that the changes in the frequency response due to positive-field and due to negative-field are not equal. This is because the holes are deflected down from the surface by the negative field and the stronger the field the more will be the bending of their paths. The higher the value of the negative field, the more will be the downward deflexion of their flow-paths towards the collector. Moreover, some of the holes would be lost by their recombination with free electrons. This recombination will increase with transit time.

But the positive magnetic field tends to concentrate the holes towards the surface and cause them to flow direct to the collector. The path of the hole-current becomes shorter with the positive-field, as the latter is increased, but cannot be shorter than the geometrical value of S, or the distance between the emitter and the collector along the surface. With stronger positive fields little improvement takes place and saturation is reached. Moreover, the recombination of the holes with the electrons is much higher at the surface of the semiconductor than inside, and this accounts for the relatively smaller change by the positive field. The output seems to reach a saturation when the field is further increased.

Voltage Amplification and Output Characteristics

The theory of the hole-current explains how the change in emitter-current causes a change in the collector-current; but it is not fully understood how ΔI_c can be larger than ΔI_e. It is believed that there is some sort of alteration of the space charge in the barrier layer at the collector by the hole-current. It is better, according to Bardeen[3], to think of the hole-current from the emitter as modifying the current-voltage characteristics of the collector rather than as simply adding to the collector current. It has not been possible to detect, if the collector barrier-layer is directly

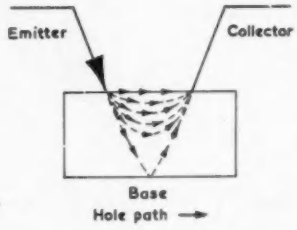

Fig. 2. The flow of 'holes'

affected by the applied magnetic field, but it has been observed that both voltage and current amplification do change by the transverse magnetic field. They increase or decrease according to the polarity of the magnetic field.

If F_b is the field in the barrier layer and μ_h the mobility, the drift velocity (v) is given by

$$v = F_b \cdot \mu_h \quad \ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{The hole-current} = I_h = n_h \cdot e \cdot v \cdot A_c \quad \ldots\ldots\ldots\ldots\ldots (5)$$

where n_h = hole concentration in the barrier

A_c = area of collector contact.

From which

$$n_h = \frac{I_h}{e \cdot v \cdot A_c} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

The numerical value of n_h in a point contact n-type germanium transistor is of the same order as the concentration of electrons, and it is quite possible that the hole-current alters the space charge in the barrier quite significantly, thus changing the collector current to such an extent that $\alpha > 1$. The net effect of the hole-current from the emitter of the n-type point contact transistor is to increase the conductivity of the germanium in the vicinity of the collector. The electrical conductivity is directly proportional to the product of carrier concentration (n_h) and the mobility (μ_h). In Fig. 3 the collector resistance (static) has been demonstrated in the $V_c - I_c$ curve under three conditions,

0 gauss, +10kG, and −10kG field strength, and, of course, for constant emitter current. In Fig. 2, one sees clearly how the collector current increases, or, decreases by the positive or negative magnetic field for different collector voltages. As shown in equation (6) the hole concentration, which causes the change in the collector resistance is directly proportional to the hole current. How the hole concentration

affects the barrier resistance at the collector is not very clearly understood. But it is obvious that the applied magnetic field controls the flow of holes from the emitter to the collector and indirectly changes the $V_c - I_c$ characteristic curve. Suhl and Shockley[4] had experimentally observed that transistor action is obtainable at the collector in the presence of a magnetic field when the collector is physically spaced further away from the emitter, than it is possible to space it when the magnetic field is turned off. In the presence of the magnetic field of proper polarity the diffusion of the holes is controlled and the hole-current is made to flow more nearly in a straight line. With the

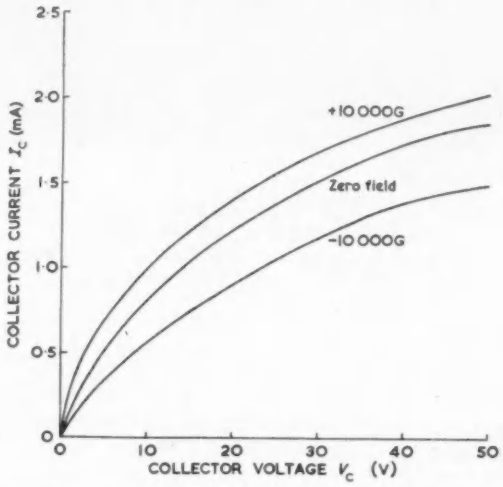

Fig. 3. Effect of magnetic field on conductivity

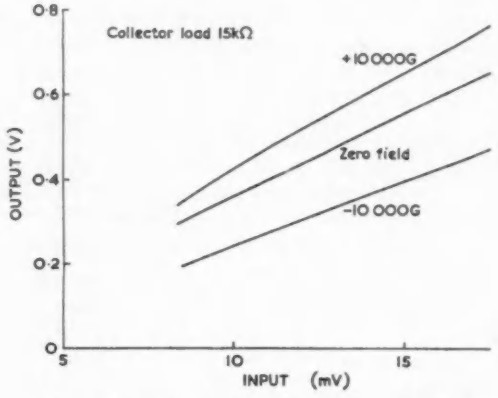

Fig. 4. Effect of magnetic field on voltage amplification

opposite polarity the path will be curved. as mentioned before.

But the distortion in the path of the hole-current alone is not responsible for the alteration of the collector-current. The deflected path increases the effective separation S between the emitter and the collector contact points, which results in phase dispersion, increase of the transit time of the carriers, and thus affects the frequency response of the transistor. The most important effect of the increase of transit time is the decay of the injected carriers by recombination with excess electrons. In other words, a strong magnetic field reduces the hole-current. Hole-current is attenuated exponentially by the recombination with electrons in going from the emitter to collector. If $N(o)$ is the original number of injected holes, the number existing after time t is

$$N(t) = N(o) \exp(-t/\tau_p) \quad \ldots\ldots\ldots\ldots \quad (7)$$

where τ_p is the lift time of the positive carrier or holes. If T be the transit time of the holes, the hole-current will be decreased by a factor $\exp(-T/\tau_p)$.

τ_p is not a very constant quantity. It varies with temperature, and also from crystal to crystal due to the presence of chemical impurities and imperfections in the lattice. When the magnetic field is applied, the transit time (τ) increases, causing an attenuation of the hole-current, which results in the change of characteristics of the collector current.

In Fig. 4 the voltage amplification curves are shown for a constant frequency of 500c/s under positive and negative magnetic fields of 10kG. Here also the variation due to positive field is less than that due to negative field.

In all these experiments the field was reversed by rotating the transistor axis through 180°. The magnetic field had no effect at 90°, i.e., when the plane of emitter and collector coincided with the applied field.

Conclusion

This article has attempted to show how the basic mechanism of current flow in a point-contact transistor is affected by a magnetic field. It has been shown that all the changes in the transistor characteristics can be attributed to the disturbance of the flow of the injected carriers by the magnetic field. Briefly, the effects of the magnetic field on transistor operation are: (1) the effective separation S between the emitter and the collector is altered. (2) The concentration of the injected carriers in the vicinity of the collector is altered. (3) The recombination rate of the injected carriers with the excess electrons is also affected due to the changed transit-time of the carriers by the magnetic field.

The experiments have been limited to point-contact transistors only as junction-transistors with non-magnetic leads were not available. The lead wires of all the available junction transistors were highly magnetic and almost shielded the transistor against the field.

Because of the extremely small separation between the emitter and the collector (~0·005cm for 20dB gain) a comparatively high magnetic field is necessary to get an appreciable change at the output. Any deviation of the operational characteristic due to stray magnetic fields is out of the question. In the experiments carried out, both emitter current and collector current changed when the field was applied. The emitter current was then re-adjusted to its previous value in order to find out how much the collector current changes by the magnetic field alone. A high resistance was put in the emitter circuit to minimize the variation of I_e due to feedback action.

Acknowledgments

The author would like to express his thanks and appreciation to Prof. H. Rakshit, Head of the Communication Engineering Department for his interest and assistance and also to Prof. Sukumaran, Head of the Electrical Engineering Department for supplying the electromagnet for the experiments. He is further indebted to Mr. M. K. Achuthan for helping in carrying out the experiments.

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Electronic Musical Instruments in Germany

By Alan Douglas, M.I.R.E., M.Amer.I.E.E.

Comparatively little has been disclosed about developments in electrical music abroad since the last war. This article presents a short summary of some of the more interesting German designs. These include the AWB organ, which is a full-scale model with two manuals and pedal and is an example of an additive sine wave circuit using valves. Several rather novel instruments are also described.

ALTHOUGH Duddell and de Forest produced musical sounds by electronic means prior to 1920, the first real musical instruments were designed by Oskar Vierling and Friederich Trautwein in 1928. At that time, gas tubes (which had reached a high state of development in Germany) were preferred as relaxation oscillators. A notable advance was made by Welte in 1936 when he produced a photo-electric instrument with rotating glass disks carrying fully preformed tone colours.

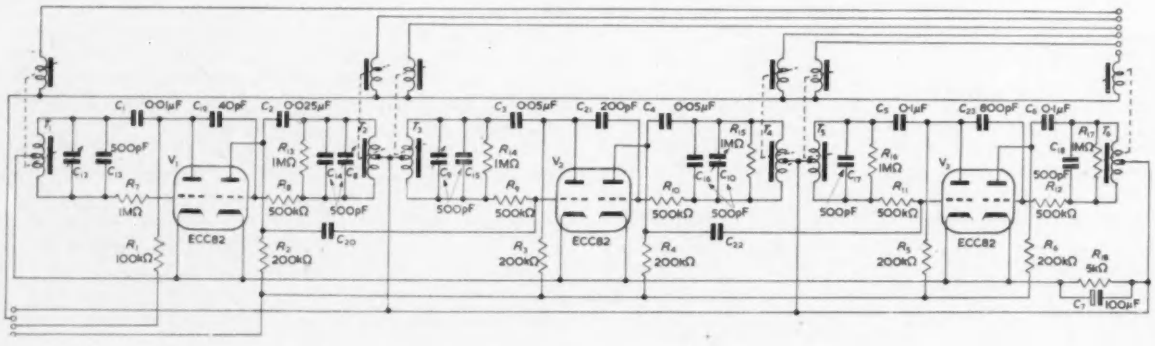
The production of non-essentials was slow in a country impoverished by war, but more recently some interesting instruments have been commercialized in Germany. Perhaps the best-known example is the AWB organ. This is a full-scale model with two manuals and pedal and is the only example of an additive sine wave circuit using valves. Fig. 1 shows the oscillator and dividers for one note sign; these latter are of the blocking type, each being tuned to the required frequency and synchronized with the previous one by the small capacitors of 40,100,200,400 and 800pF. A coupling coil, shown above the oscillatory circuits, conveys the signals to the busbar system.

Keying is carried out in a manner similar to that of the Hammond, six different pitches being available at the busbars. From the multiple key contacts the signals are taken to a tapped mixing transformer through 'antirobbing' resistors of 200Ω each as in Fig. 2, which shows part of the pre-amplifier circuit. The harmonic reduction and transient filters to ensure pure sine waves can be seen following the input transformers.

Extensive stabilization of the power supplies is required in an additive instrument, and the circuit for this (which incorporates the vibrato oscillator) is shown in Fig. 3. The use of mutations such as tierce and twelfth endows this organ with great brilliance of tone and without doubt the upper work is better developed in the AWB than in any other electric organ. Recently this instrument has been completely redesigned to incorporate transistor oscillators, although at the moment no exact details are available. A

The photograph shows the designer, Oskar Sala, at the keyboards of the concert model Trautonium

Fig. 1. AWB oscillator and dividers



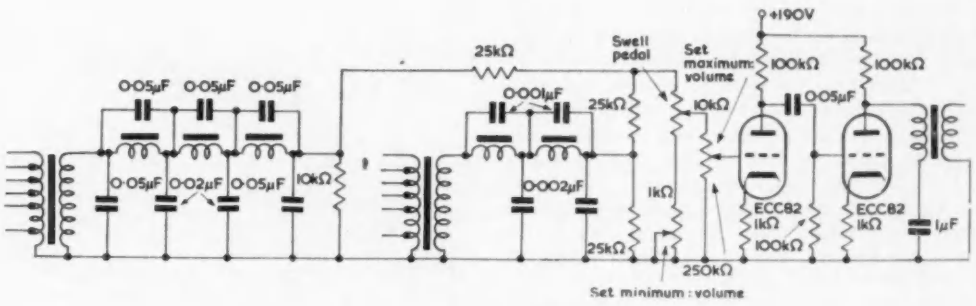


Fig. 2. Part of AWB pre-amplifier circuit

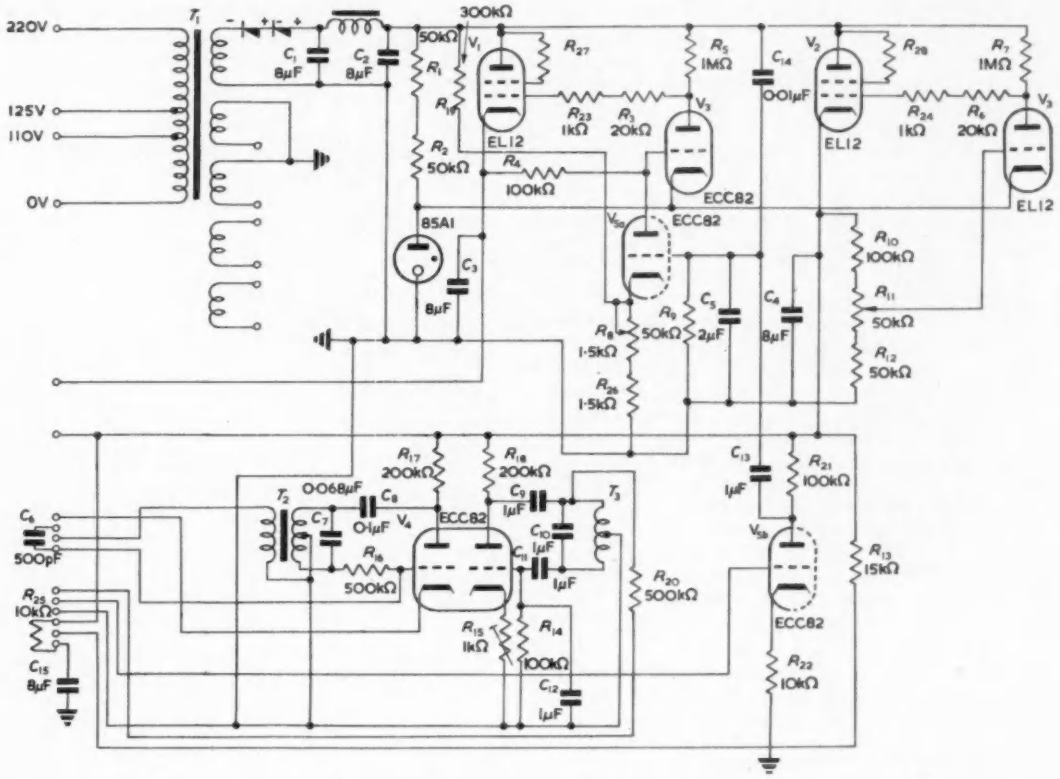


Fig. 3. Stabilized power supply and vibrato oscillator

similar, though not quite so elaborate, instrument designed by Harald Bode is marketed by Haeberlein of Munich.

The firm of Matth. Hohner AG, known for many years as makers of harmonicas, produces several electrical novelties. Apart from the Clavioline made under the Seybold patents and re-named the Electronium P1 when supplied in the usual form with a keyboard, another model is made in which the expression control is worthy of note. Fig. 4 is a photograph of the interior, from which it can be seen that the tone generator is played by accordion keys but the bellows fulfil a double function. If compressed at one end, a rheostat alters the volume, while if compressed at the other end, the harmonic content is changed by moving a coupling coil away from another coil fixed to this instrument. Otherwise the controls are arranged as for the Clavioline and this model may also be obtained with buttons in place of keys.

A rather quaint device is the Multimonika, shown in Fig. 5. Here there are two keyboards each of 41 notes compass. The lower one operates three sets of reeds which are contained within the case together with a small blowing fan. Different sets of reeds may be selected by pressing the buttons shown and the reed volume is regulated by a knee-operated shutter controlling louvred openings in the case. The upper manual is electronic and only one note at a time may be played thereon. The circuit, Fig. 6, is

reminiscent of the earlier Solovox, the tone oscillator frequency being altered by removing capacitors from the main tuning circuit. The vibrato oscillator uses a gas tube and a tuning control appears on the front panel to set the pitch to that of the reeds; also on this panel are the tone switches.

Hohner also make a reed accordion with acoustic insulation and a microphone to pick up the sound. A preamplifier allows the reed tones to be altered in many ways by formant circuits. Another useful product is the Bassophon, designed to simulate either the string base or the tuba, but playable by keys. The controllable attack allows very rapid speech over its two and a half octaves, and additional amplifiers may be paralleled to increase the volume of sound.

Turning to more serious developments, the instruments used by the Cologne school of music research comprise the Melochord and Trautonium.

Fig. 5. Hohner Multimonika

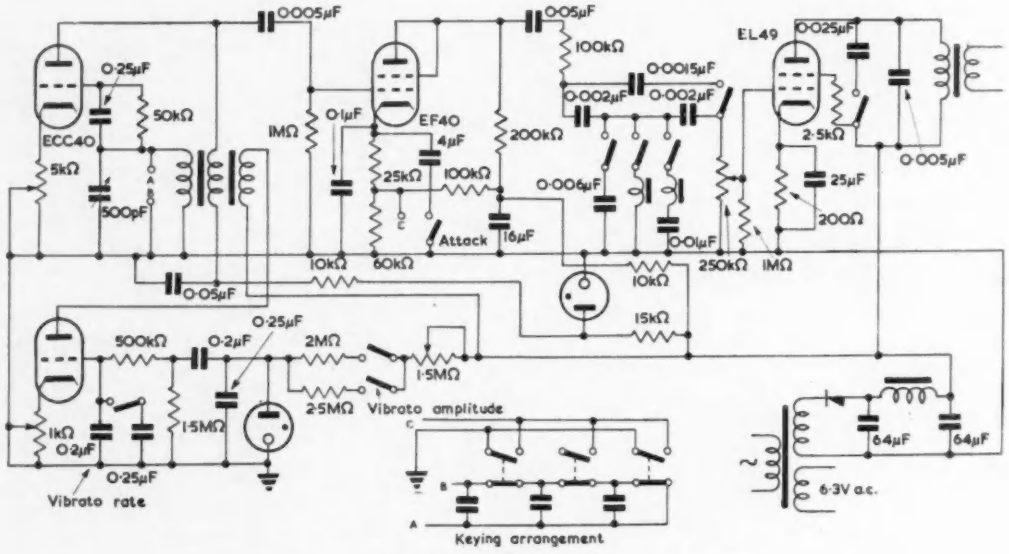


Fig. 6. Circuit of Multimonika

Fig. 4. Hohner Electronium showing expression control

Both of these devices have been described previously[1]. While their primary purpose is for research on musical tone qualities and the composition of 'new' music, a concert model of the Trautonium has been developed by Oskar Sala for use with a conventional orchestra, and has an amplifier of 150W output so that the power level can equal that of the orchestra if required[2]. The photograph on page 642 shows the designer at the keyboards of this Trautonium, the frequency dividers of which are unique in that the harmonic content per octave is controlled by the method of division, the object being to apply tone filters of varying characteristics for each octave and not, as is more usual, to feed the whole signal into common shaping networks. By this means, octaves below the fundamental can be heard with quite different timbres, forming some very attractive sound patterns.

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Diode Hole Storage and 'Turn-on' and 'Turn-off' Time

By G. Grimsdell*

This article describes both the 'turn-on' and the 'turn-off' circuit effects in a typical germanium diode and shows why it is dangerous to compare diodes by their published hole storage times, without at the same time considering the conditions of measurement in each case.

VALVE diodes behave more or less according to their theoretical prediction when fed with a train of voltage pulses. The current through the diode starts and stops according to the instantaneous polarity across the diode, and only the small physical capacitance of the diode has any adverse effect, at any rate at ordinary frequencies when transit time has little significance.

With the semiconductor diode, however, the position is very different, and unwanted effects occur both at the beginning and end of the current pules.

'Turn-on' Time

When a diode which has been biased in the reverse (high impedance) direction suddenly has its polarity reversed (low impedance direction), the forward voltage drop across the diode for a given current is higher immediately after the reversal than it would be under steady state conditions (see Fig. 1).

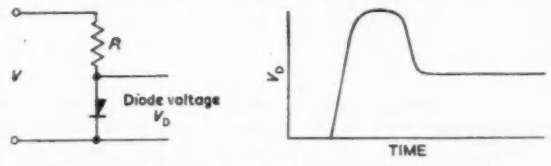


Fig. 1. The diode circuit and its 'turn-on' characteristic

This phenomenon is hardly noticeable in point contact diodes due to their limited maximum current and high forward voltage drop, but in gold-bonded and small-area junction diodes, where these factors have been improved, it can be the next important effect.

The phenomenon appears to be due to the fact that when a diode is conducting and its base is flooded with 'carriers' the base resistance is lower than when the first carriers pass the junction but have gone no further, i.e., the effect is due to the modulation of the base resistance by the injected carriers.

It is worse when the diode is used at high currents with low circuit impedances and sharp waveforms. Diodes specially produced for use in computers and other digital circuits must of course have this property controlled to a point where it does not affect the operation of the circuits using the diode.

'Turn-off' Time and 'Hole Storage'

When a diode has been carrying current in the forward direction and the voltage across it is suddenly reversed, the high current through the diode does not immediately cease but flows for a small time in the reverse direction.

The effect is due to the fact that when the diode is in forward conduction, minority carriers are injected into the base, and these flood a large volume of the germanium. When the polarity is then reversed, these minority carriers are thus available to provide a short burst of high reverse current, before the diode settles down to its normal low leakage current.

Assuming for the moment that the minority carriers do not recombine in the bulk of the base material, it will be seen that for any forward current there will be a fixed charge of carriers available to flow in the reverse direction on polarity reversal. The rate of reverse flow of this charge and therefore the time for the flow to decrease to a given value will depend among other things, on the external circuit resistance. Indeed, it would be possible to stop the forward current flow, wait a small fraction of time, and then to apply the reverse voltage and still get the hole storage current.

In fact, if the circuit impedance were low enough, very large currents could be drawn from the diode for very short times, the diode emptied of carriers and made ready for use as a normal diode much sooner.

There are, however, two other phenomena that must be taken into account. Firstly, spontaneous recombination (carrier lifetime) and secondly, minority carrier transportation by diffusion.

Recombination takes place all the time and minority carriers have themselves an average expectancy of life. Thus, if the base region of a diode is full of minority carriers, because the diode has been conducting in the forward direction, and the current is cut off, it will be found that on the later application of the reverse potential the available hole storage charge is less than was expected. In fact, whether the external circuit values affect the hole storage time of the diode or not, will depend upon whether the circuit drive pulse and rise-times are long or short compared with the average life-time of the minority carriers.

In the extreme case the carrier life-time is made so short that there can never be any measurable hole storage because they all recombine before they are recalled to the junction at the reversal of polarity.

In the same way, a reduction in the bulk of the germanium will reduce the hole storage simply because there is less space to store them in, quite apart from the closer proximity of the surface effects.

Specification of Hole Storage in Published Data

The actual hole storage properties of a diode can be specified in a number of ways: in terms of the total charge immediately available on potential reversal; as the time taken for the large reverse current to die away to a given value through a given resistance; the reverse current reached after a given time; or as the peak current in a given circuit. However, all these methods are dependent both on the measuring circuit parameters and on the ratio of contribution made to the hole storage performance of the diode under test by the volume and geometry of the base, by the life-time and other properties of the germanium, and by the forward current originally passed through the diode.

* *Mullard Ltd.*

Thus, two types of diode may be co-related between the various types of test at one or more measuring points, while a third diode, in which the contribution of the different diode phenomena occurs in different amounts, will fail to co-relate at all between various test circuits and will perhaps appear better than some other type in one test and worse in another test.

Much argument at present exists as to the best method of measuring hole storage and presenting it in published data. So far, although some standard tests exist, it is not really possible to infer diode performance in every circuit from one value of hole storage in one standard circuit.

In time, perhaps, suitable constants will be found to specify completely the diode's hole storage under all conditions.

In the meantime, all the manufacturer can do is to give the hole storage data in a specified circuit at specified currents which are as near as possible to the user's circuit requirements.

The user must, in his turn, realize that the hole storage time of a diode can only be meaningful if the circuit and current are also quoted.

The coming of small area junction diodes and the gold bonded diode makes this precaution even more necessary, since the range of their operating forward currents is much larger and hence hole storage becomes more important.

Acknowledgment

The author wishes to thank the Directors of Mullard Limited for permission to publish this article.

A Constant Voltage — Constant Current Stabilizer

By D. P. C. Thackeray*, B.Sc., A.Inst.P.

Uses are suggested for a stabilizing arrangement which will switch itself automatically between constant voltage and constant current operation, to suit the load or overload demands made upon it A circuit is developed to suit the particular demands of an electronic photo-flash unit.

DESIGNERS and constructors of stabilized power supplies are well served by a considerable literature, describing in greater or lesser detail practically every permutation and combination of available components. It is perhaps not realized widely enough that completed stabilizers, by virtue of their stabilizing action, need to be designed against misuse.

For example, a constant voltage d.c. stabilized power supply unit, when connected to an uncharged capacitor, may readily switch itself into a condition of considerable current overload until the capacitor is charged. A similar voltage overload may appear when a constant current flow is established in an inductor. Neither application can be deemed unusual in general instrumentation practice, but clearly the damage done by such peak overloads will be more marked when high voltage or high current apparatus is concerned. Thus, while it may be sound practice to design medium voltage and medium current stabilizers with some leeway to meet peak demands, at higher voltages or currents it may be economically worthwhile to consider methods of automatic protection.

Automatic Overload Protection

Consider a simple case, for instance that of Fig. 1, where a battery may be used to charge a capacitor when a switch is closed. The peak current may be limited to a suitable safe value by choice of an appropriate value for the series resistor. Such a resistor inserted in series with a stabilized voltage supply would be a possible, though inelegant, protective device. In general, and depending upon whether the resistor followed or preceded the stabilizer, the source impedance of the combination would be high enough, either to spoil the regulation of the supply, or to present a large voltage drop at full load current. A better position for the resistor in such a supply is shown in Fig. 2, where it has been inserted in series with the cathode of the series control valve. Here the resistive effect of valve plus resistor R_k, as far as current changes are concerned, is now $[(r_a/R_k) + \mu]$ times that of a resistor R_k alone, where μ is the amplification factor of the series valve, and r_a its anode impedance. Hence the resistor may be smaller by this factor, for the same degree of protection, in which case it will drop only what may be a negligible fraction of the voltage drop of the simpler case. The insertion of this resistor results in some degradation of the stabilization obtainable, but this may readily be countered by a suitable increase in the gain of the shunt amplifier stages(s).

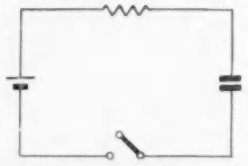


Fig. 1. Simple current limiting circuit using a resistor
The source impedance is increased and the charging current waveform constrained to an exponential shape

In the more elaborate form of this stabilizing circuit, it may be necessary, Fig. 3, to insert a diode to ensure that during overloads, the grid of the series valve is returned effectively to the correct point. In practice it is convenient in either circuit to make the inserted resistor variable, so that the peak overload current may be adjusted to a suitable value.

Constant Current—Constant Voltage Operation

It can be seen that, if the load on a modified stabilized supply, such as that of Figs. 2 and 3, is switched from an open-circuit to a short-circuit, the stabilizer will change from supplying a stable voltage, to supplying a current determined principally by the series valve and its cathode

* *Vickers Group Research Establishment, formerly Research Laboratory for the Physics and Chemistry of Solids, Department of Physics, Cambridge.*

resistor. Since such a combination provides a dynamic resistance, for current changes, many times the quotient voltage ÷ current, it can be considered as a current stabilizer, albeit of a simple type. Thus it may be used to charge a capacitor at a constant rate. When the capacitor has charged to a voltage equal to that at which the voltage stabilizer normally provides a controlled output, the charging current will fall to zero, and the stabilizer will revert to holding constant the voltage across the capacitor. The change from one condition to the other will be more or less abrupt, depending upon whether the shunt amplifier stage(s) has a high gain and is turned on rapidly from cut-off to its working point, or has a low gain and is turned on slowly. If it is desirable to set a limit to the power that may be drawn from such a device, the less abrupt characteristic may be tailored to reach this limit at a suitable point on the regulation characteristic. These properties may be exploited in, for instance, a power supply unit, Fig. 4, designed to charge the capacitor bank of an electronic flash unit. This unit has been used in the research programme of the laboratory for the photo-irradiation of explosive materials. The automatic recharging of the bank after each flash, to a constant voltage, will relieve the operator of an onerous duty, when it is desirable to hold this voltage to within a few per cent over long periods of operation. The constant rate of charge has two advantages, by comparison with resistive charging. First, the slower initial rate of charge allows the flash discharge tube better to deionize after the previous flash. Second, the faster ultimate rate of charge avoids the lengthy exponential approach to the final voltage.

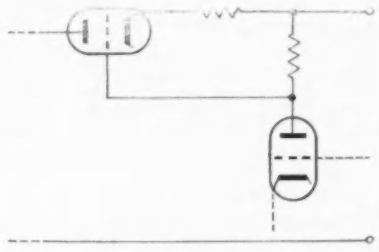


Fig. 2. Use of limiting resistor in cathode of series valve of a series-parallel stabilizer

This increases the dynamic impedance by μR_k, thereby reducing the overload currents that can be drawn from the stabilizer

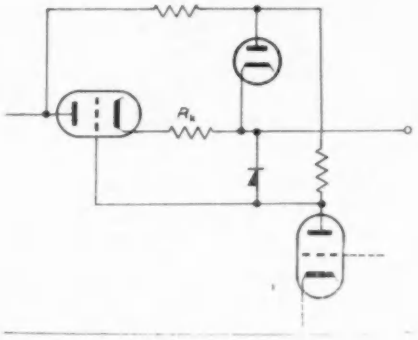
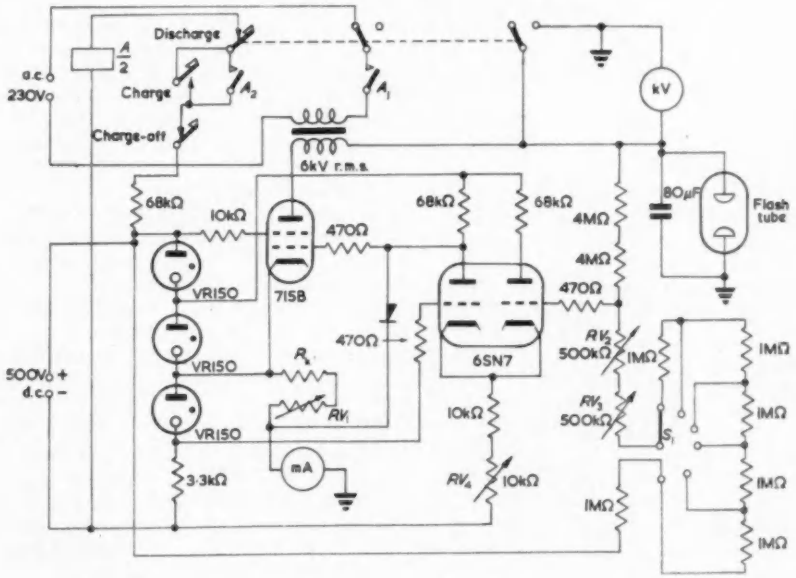


Fig. 3. Insertion of 'catching diode' to prevent grid voltage of series valve rising above output voltage of the unit

If the series valve is a tetrode or pentode its screen grid can be fed from the gas-filled voltage stabilizer to raise its dynamic impedance still further

Referring to Fig. 4, R_k and RV_1 together form the resistance controlling the charge rate, which is normally set to between 5 and 20mA. RV_2 and RV_3 and S_1 are used to set the controlled output voltage to any required value in the range −700V to −3·7kV. The series valve, a 715B, may dissipate up to 60W on its anode, a demand which this operation may frequently entail. It combines this function with that of a rectifier, since the addition of a separate rectifier serves no useful purpose in such a unit. Further to simplify operation, the unit is switched by means of push-buttons and a contactor, the latter interlocked with a discharge switch for the capacitor bank, and one of the main e.h.t. switches. Thus the unit when enclosed is proof against accidental mis-operation, and suffers no damage when the capacitor bank is discharged.

Fig. 4. Power supply for an electronic flash unit



Conclusion

It has been shown that a simple modification will protect stabilized supplies against accidental overloads. The device is readily applicable to stabilizers designed to work between conditions of zero current, stabilized voltage, and full load current at voltages below this. The transfer from one state to the other is automatic, and is a particularly useful feature for reliable equipment, and where the operator must devote his attention principally elsewhere.

Acknowledgments

Thanks are due to Dr. G. T. Rogers, for drawing the attention of the author to the potential value of an automatic power unit, and to S. Barton and J. Ward for constructional work on the prototype and final unit.

TIME-SYMMETRIC FILTERS

(Part 2)

Response to Gliding Tones

By L. R. O. Storey*, M.A., Ph.D., and J. K. Grierson*, M.Sc.

In Part 1 of this article, methods were described for simulating filters that have impulse responses that are symmetrical in time. Their application to the analysis of gliding tones is now discussed. The response of a narrow-band time-symmetric filter to a gliding tone is evaluated, and is shown to consist of an oscillation bounded by a slowly-varying envelope. The shape of the envelope is governed by a single dimensionless parameter, that involves the bandwidth of the filter and the rate of variation of the instantaneous frequency of the tone. There is an optimum value of this parameter that yields the sharpest response.

In general, the envelope of the response is symmetrical, and reaches a maximum at the time when the frequency of the tone is equal to the resonant frequency of the filter. This behaviour contrasts with that of a simple tuned circuit. Use of the time-symmetric filters, instead of simple tuned circuits, should lead to greater accuracy in the analysis of gliding tones.

THE aim of this study was to improve upon the techniques in current use for the analysis of gliding tones.

A gliding tone is a quasi-sinusoidal oscillation that can be represented as the resolved part of a vector of constant or slowly changing amplitude that rotates at a variable speed. Suppose, to be definite, that the tone is in the form of an electrical voltage. Then the variation of voltage with time is given by such an expression as

$$V(t) = V_0 \sin \phi(t) \tag{48}$$

The *instantaneous frequency* of the tone is defined as

$$f = \frac{1}{2\pi}\left(\frac{d\phi}{dt}\right) \tag{49}$$

and is assumed to vary only slowly with time: slowly, that is, compared with the oscillation itself. Variations in the amplitude V_0, if any, are assumed to be slow also.

The particular problem in hand is that of the analysis of certain experimental data that are recorded as waveforms on magnetic tape. Each record consists of a gliding tone, or a closely-spaced sequence of such tones, mixed with varying amounts of unwanted noise. The object of the analysis is to determine, for each tone, how its instantaneous frequency varies with time. This is done usually by means of narrow-band filters. The time when the instantaneous frequency takes a particular value is measured by passing the tone through a filter tuned to that frequency, and then noting when the response of the filter rises to a maximum. The complete relationship between frequency and time is determined by repeating this measurement at a number of different frequencies, either simultaneously using a number of filters, or, if a recording of the tone is available and can be played back many times, sequentially using a single filter tuned to the different frequencies in turn.

Questions arise as to what type of filter should be used, and what bandwidth it should have, in order to resolve adjacent tones most completely and to discriminate most effectively against interfering noise.

In the past much use has been made of the resonant *LC* circuit, because this is the simplest type of narrow-band filter. The response of this circuit to a gliding tone has been evaluated by Barber and Ursell[8], and by Barber[9]. They find that it consists of an oscillation bounded by a relatively slowly-varying envelope, and that the shape of the envelope, though complicated, depends on a single parameter k that involves the bandwidth of the filter and the rate of change of the instantaneous frequency of the tone; this parameter will be defined shortly. Fig. 6 shows how the envelope varies with time, for several values of k. The origin has been set at the moment of resonance; that is to say, the moment when the frequency of the tone is equal to the resonant frequency of the filter. When analysing a tone, each individual measurement consists of determining one such time by inspecting one such response.

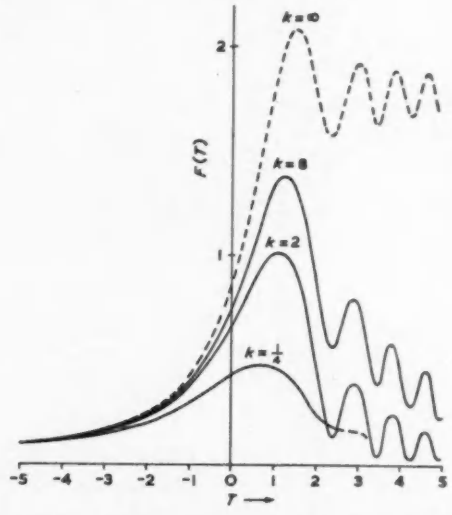


Fig. 6. Envelopes of the response of a simple tuned circuit to a gliding tone, for different values of the parameter k. The abscissa T is a normalized measure of time, and its origin is set at the moment of resonance (after Barber and Ursell)

In general, the response is asymmetrical in time, and reaches its maximum somewhat after resonance. Its leading edge rises smoothly, but its trailing edge contains pronounced ripples; these may be understood as beats between a forced oscillation, at the frequency of the tone, and a transient oscillation, at the natural frequency of the circuit, which is excited around resonance and subsequently decays.

Now responses of this type do not lend themselves to making very accurate analyses, for the following reasons:—

Firstly, because of the asymmetry, a correction must be applied to the observed time of maximum response to obtain the time of resonance. The amount of this correction depends on the value of k, being greatest when k is large.

* *Defence Research Telecommunications Establishment, Candaa.*

Secondly, the ripples on the trailing edge cause confusion when attempting to resolve a number of adjacent gliding tones. The envelope of the response then exhibits many closely-spaced peaks, and it is hard to tell which are due to multiple tones and which are just subsidiary peaks in the response to a single tone.

Clearly, it would be better if the main maximum of the response of the filter occurred at resonance for all values of k, and if the subsidiary maxima were smaller and less numerous.

Now the reason that the peak of the gliding tone response of the resonant LC circuit is delayed is that its frequency response contains phase-shifts, or, what amounts to the same thing, that its impulse response is asymmetrical in time. A narrow-band filter that had a time-symmetric impulse response would not produce this delay, but such filters are not physically realizable. Fortunately, however, simple methods exist for simulating their effects artificially. These methods, which are particularly applicable to tape-recorded data, have been described fully in Part 1 of this article, where results were presented to show how a narrow-band 'time-symmetric filter' could be derived from parallel-tuned LC circuit. Part 2 now presents a discussion of the applicability of this filter to the analysis of gliding tones.

The content of Part 2 is arranged as follows: First, Barber and Ursell's analysis for the straightforward case of the tuned LC circuit is reviewed and summarized. The properties of the time-symmetric filter are then quoted, and its response to an arbitrary waveform is shown to be related quite simply to that of the parallel-tuned circuit from which it is derived. On this basis, its gliding tone response is evaluated by making use of the results of the earlier analysis. Next, the question of the best value of k to use when analysing a gliding tone is discussed, both for the simple tuned circuit and for the time-symmetric filter; the optimum responses of the two filters are compared, and their predicted shapes are confirmed experimentally. The results are then summarized and discussed. Finally, in an appendix, the possibility of using a series-tuned circuit, instead of a parallel-tuned circuit, is examined.

The Response of a Parallel-tuned Circuit

Barber and Ursell, in their original paper[8], dealt with a mechanical resonant system, the electrical analogue of which is a series-tuned circuit; they calculated its response to a gliding tone of steadily falling pitch. In reproducing their analysis here, it was found convenient to translate it into electrical terms, and to modify it slightly so as to make it apply to the parallel-tuned instead of the series-tuned circuit, and to tones of rising as well as of falling pitch. Also it has been simplified by assuming throughout that the Q-factor of the resonant circuit is much greater than unity. The notation used is that of Part 1, and the argument proceeds as follows:—

The response of a filter to an arbitrary input $V_{in}(t)$ is given by the convolution integral

$$V_{out}(t) = \int_{-\infty}^{\infty} V_{in}(t-\tau)\,u(\tau)\,d\tau \quad \text{(c.f. equation (1))}$$

where $u(t)$ is its impulse response. For a parallel-tuned circuit, the impulse response is

$$u(t) = \left\{\begin{array}{ll} 0 & (t<0) \\ \frac{1}{2}u_0 & (t=0) \\ u_0 \exp(-\pi W t)\cos(2\pi f_0 t) & (t>0) \end{array}\right\} \text{(c.f. equation (26))}$$

Accordingly, when the gliding tone of equation (48) is applied to the input, the output is

$$V_{out}(t) = V_0 u_0 \int_0^{\infty} \sin\phi(t-\tau)\exp(-\pi W\tau)\cos(2\pi f_0\tau)\,d\tau \quad (50)$$

From here on, the time t is measured from the moment of resonance, when $f = f_0$; this choice of origin involves no loss of generality.

The convolution integral (50) may be evaluated approximately by expanding $\phi(t-\tau)$ as a power series in τ, and neglecting all higher terms than that involving τ^2. Thus:

$$\begin{aligned}\phi(t-\tau) &= \phi(t) - \tau\,\phi'(t) + \tfrac{1}{2}\tau^2\,\phi''(t) + \cdots\cdots\cdots \\ &\simeq \phi(t) - 2\pi\tau f(t) + \pi\tau^2 f'(t) \\ &\simeq \phi(t) - 2\pi f_0\tau + \pi f'[\tau^2 - 2t\tau] \quad \cdots\cdots (51)\end{aligned}$$

where

$$f' = df/dt \quad \cdots\cdots\cdots\cdots\cdots\cdots (52)$$

and use is made of the approximation

$$f(t) \simeq f_0 + f'\,t \quad \cdots\cdots\cdots\cdots\cdots (53)$$

Evidently the neglect of higher terms in the power series amounts to taking f' as constant, which is to assume that the instantaneous frequency varies linearly with time through the pass-band of the filter.

By substituting this approximation for $\phi(t)$ into the convolution integral, Barber and Ursell show that the output from the filter can be expressed as the sum of two oscillatory terms, one of which is in phase with the oscillations of the original gliding tone, while the other is in quadrature:—

$$V_{out}(t) = V_0 u_0 [B(t)\sin\phi(t) + A(t)\cos\phi(t)] \cdots\cdots (54)$$

The amplitude factors, which vary with time relatively slowly, are given by

$$\left.\begin{matrix} A(t) \\ B(t) \end{matrix}\right\} = \tfrac{1}{2}\int_0^{\infty} \exp(-\pi W\tau)\left\{\begin{matrix} \sin \\ \cos \end{matrix}\right\} [\pi f'(\tau^2 - 2t\tau)]\,d\tau \quad (55)$$

The two terms combine together to form an oscillation of intermediate phase that has an envelope given by

$$E(t) = V_0 u_0 \left[\{A(t)\}^2 + \{B(t)\}^2\right]^{\frac{1}{2}} \cdots\cdots (56)$$

To obtain the shape of this envelope, the integrals for the amplitudes $A(t)$ and $B(t)$ must be examined. Now the Admiralty Computing Service has prepared tables[10] of the functions

$$\left.\begin{matrix} S(T) \\ C(T) \end{matrix}\right\} = k^{\frac{1}{2}}\int_0^{\infty} \exp(-z)\left\{\begin{matrix} \sin \\ \cos \end{matrix}\right\} (2Tk^{\frac{1}{2}}z - kz^2)\,dz \quad \cdots (57)$$

The unknown integrals can be reduced to this form by setting

$$z = \pi W\tau \quad \cdots\cdots\cdots\cdots\cdots (58)$$

$$k = |f'|/\pi W^2 \quad \cdots\cdots\cdots\cdots (59)$$

$$T = (\pi|f'|)^{\frac{1}{2}}t \quad \cdots\cdots\cdots\cdots (60)$$

The parameters z, k, and T are dimensionless, and have the following meanings:—

z is the ratio of the time displacement τ to the decay time of the impulse response of the filter (c.f. equation (26)).

k involves the bandwidth W, and also the modulus of the rate of change of frequency of the gliding tone. The latter quantity has dimensions of (frequency)^2, so that its square root $|f'|^{\frac{1}{2}}$ defines a bandwidth; this is in fact the range of frequencies around f_0 over which the different Fourier components of the tone are more or less in phase at $t = 0$. Thus k is proportional to the square of the ratio of this 'inherent bandwidth' of the gliding tone to the bandwidth of the filter[11].

T is proportional to the ratio of the time t to the duration of the period around $t = 0$ over which these same Fourier components more or less maintain their phase coherence. The meaning of T may be clarified, perhaps, by noting the

identity

$$Tk^{\frac{1}{2}} = t|f'|/W = \Delta f/W, \text{ say} \quad \ldots\ldots\ldots\ldots (61)$$

where

$$\Delta f = \pm (f - f_0) \ldots\ldots\ldots\ldots\ldots (62)$$

and where the positive sign is used for ascending tones, and the negative sign for descending tones. Thus the quantity Δf is equal in magnitude to the difference between the instantaneous and resonant frequencies, but it has the same sign as t has, so that it is reckoned negative before and positive after resonance. Equation (61) shows that, for a given value of k, T is proportional to the ratio of Δf to the bandwidth of the filter. In sum, T is a normalized measure of time.

On rewriting the integrals in terms of these parameters, the amplitudes are found to be given by

$$A(t, W, f') = \pm \frac{1}{2\pi W k^{\frac{1}{2}}} \; S(T, k) \ldots\ldots (63)$$

$$B(t, W, f') = \frac{1}{2\pi W k^{\frac{1}{2}}} \; C(T, k) \quad \ldots\ldots (64)$$

where, in equation (63), the positive sign applies to descending tones, and the negative sign to ascending tones, i.e., the sign is opposite to that of f'.

Thus the envelope of the gliding tone response is given by

$$E(t) = V_0 \frac{u_0}{2\pi W} k^{-\frac{1}{4}} \left[\left\{S(T)\right\}^2 + \left\{C(T)\right\}^2\right]^{\frac{1}{2}} \ldots\ldots (65)$$

Now, from Part 1

$$\frac{u_0}{2\pi W} = y_0 \quad \ldots\ldots \text{(c.f. equation (28))}$$

where y_0 is the amplitude of the frequency response of the filter at resonance.

So, finally,

$$E(t) = V_0 y_0 \left\{k^{-\frac{1}{4}} F(T)\right\} \quad \ldots\ldots\ldots\ldots (66)$$

where

$$F(T) = \left[\left\{S(T)\right\}^2 + \left\{C(T)\right\}^2\right]^{\frac{1}{2}} \ldots (67)$$

Values of the function $F(T)$ are given in the Admiralty Computing Service tables[10], and are reproduced in some tables prepared recently by Grierson and Parr[12]. Fig. 6 shows graphs of $F(T)$ for certain selected values of k; this figure is similar to Fig. 1 of Barber and Ursell's paper. The main features of these graphs have been discussed already, but it is worth noting again that the shape depends on the bandwidth W and the sweep rate f' only through their combination in the dimensionless parameter k. Also, as k involves only the magnitude of f' and not its sign, the envelope of the response has the same shape, at a given rate of frequency sweep, whether the frequency is rising or falling.

It is easy to show that, in the limit of very large k (high sweep rate or narrow bandwidth), the response near $T = 0$ reduces to the form indicated by the broken line in Fig. 6; this distribution is familiar in optics, where it is encountered in the problem of Fresnel diffraction at a straight edge. In the opposite limit of very small k (low sweep rate or wide bandwidth), the gliding tone response simply follows the frequency response curve of the filter (equation (21)).

The Time-Symmetric Filter

In Part 1 methods were presented for simulating a filter that has the following time-symmetric overall impulse response:

$$U(t) = U_0 \exp(-\pi W|t|) \cos(2\pi f_0 t) \quad \text{(c.f. equation (30))}$$

This is related to the impulse response of a parallel-tuned circuit by the expression

$$U(t) = \frac{U_0}{u_0} \left\{u(t) + u(-t)\right\} \quad \text{(c.f. equation (29))}$$

where $u(t)$ is given by equation (26) and $u(-t)$ is its time-reverse.

Evidently, to find the overall response of the time-symmetric filter to any waveform, it is necessary only to calculate the corresponding responses for the simple parallel-tuned circuit, first with the impulse response the normal way round, and secondly with it reversed, then to add the two results, and finally, to multiply by the amplitude factor U_0/u_0. The gliding tone response of the parallel-tuned circuit has been evaluated in the preceding section, and in the section which now follows the result is applied to yield the overall gliding tone response for the time-symmetric filter.

The Overall Response

The first step in calculating the overall response of the time-symmetric filter is to find out how the gliding tone response of the simple parallel-tuned circuit would be altered if somehow its impulse response was reversed in time. The output from the circuit would be given by

$$V_{out}(t) = \int_{-\infty}^{\infty} V_{in}(t-\tau)\, u(-\tau)\, d\tau \quad \text{(c.f. equation (1))}$$

$$= \int_{-\infty}^{\infty} V_{in}(t+\tau)\, u(\tau)\, d\tau \quad (68)$$

where V_{in} is in the gliding tone of equation (48). On developing the analysis as before, the following result is obtained:

$$V_{out}(t) = V_0 u_0 [B(-t) \sin\phi(t) + A(-t) \cos\phi(t)] \quad (69)$$

where $A(t)$ and $B(t)$ are given by equation (55) as before. This result may be compared with that of equation (54) which applies to the circuit when its impulse response is the normal way round. These two results may now be combined to give the overall response of the time-symmetric filter to the gliding tone:

$$V_{out}(t) = V_0 U_0 \left[\left\{B(t) + B(-t)\right\} \sin\phi(t) + \left\{A(t) + A(-t)\right\} \cos\phi(t)\right] \ldots (70)$$

The envelope of the response is

$$E(t) = V_0\, U_0 \left[\left\{A(t) + A(-t)\right\}^2 + \left\{B(t) + B(-t)\right\}^2\right]^{\frac{1}{2}} \quad (71)$$

By manipulations similar to those by which equation (66) was obtained from equation (54) this expression may be reduced to the final form

$$E(t) = V_0\, Y_0 \left\{\tfrac{1}{2} k^{\frac{1}{4}}\, G(T)\right\} \quad \ldots\ldots\ldots (72)$$

where Y_0 is the amplitude of the overall frequency response at resonance, and

$$G(T) = \left[\left\{S(T) + S(-T)\right\}^2 + \left\{C(T) + C(-T)\right\}^2\right]^{\frac{1}{2}} (73)$$

This function represents the shape of the envelope. Its values have also been tabulated by Grierson and Parr[12]. In Fig. 7 $G(T)$ is plotted out for the same values of the parameter as apply to the graphs of Fig. 6. The envelope of the response is seen to have its maximum value at resonance ($T = 0$) for all values of k, and also to be symmetrical about this point, as is obvious from the form of equation (73). This behaviour contrasts with that of the simple tuned circuit. If the corresponding responses of the two filters are compared, the time-symmetric response is seen to be slightly broader in its main peak, but its subsidiary peaks are much reduced in relative amplitude.

In the limit of large k, $G(T)$ reduces to a constant value of $\pi^{\frac{1}{2}}$ (the broken line in Fig. 7); this result may be understood

to mean that the filter simply picks out the Fourier component of the signal at the frequency f_0. In the limit of small k, $G(T)$ reproduces the overall frequency response curve of the filter (equation (23)).

Optimum Conditions for Analysis

The problem to be considered now is that of the best value of k to use when analysing a gliding tone with a filter of a given type. The simple tuned circuit and the time-symmetric filter are considered separately, and the optimum k is found for each; the gliding tone is assumed to be given, so that the sweep rate f' is fixed, but k may be varied by altering the bandwidth W of the filter (c.f. equation (59)). Later the optimum responses are compared, and in this way the relative merits of the two types of filter are examined.

Now the choice of k would present no problem if the record contained just a single gliding tone, without any noise. In such a case the time of maximum response could be measured exactly, whatever the value of k, so all values

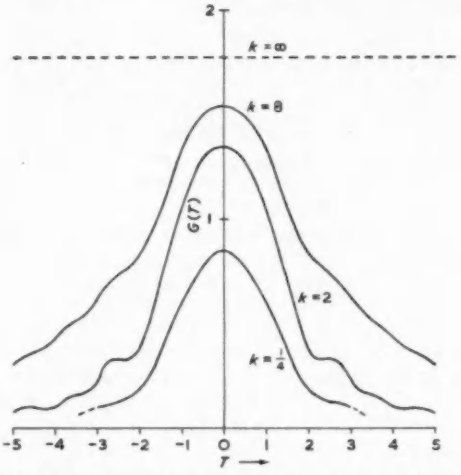


Fig. 7. Envelopes of the response of the time symmetric filter

would be equally useful. But in the present application (see above) the analysis of each gliding tone is confused by interference from other, neighbouring tones and from spurious noise. The optimum k is that value which leads to the most accurate measurements in the presence of these sources of interference.

Consider first the problem of discriminating against neighbouring tones. Clearly, for this purpose, the response should be as sharp as possible, i.e., its width should be a minimum. The measure of the width of the response that will be adopted here is the interval of normalized time T between the two '6dB points', that is to say, the points where the amplitude is half the maximum value. Fig. 8 shows how this quantity varies with the parameter k, both for the simple tuned circuit (curve A) and for the time-symmetric filter (curve B). From inspection of these curves it appears that the response of the tuned circuit has minimum width at about $k = 4$*, while the minimum for the time-symmetric filter is near $k = \frac{1}{2}$. Both minima are broad, so the choice of k is clearly not very critical.

Now consider the problem of discriminating against noise. The following general argument shows that, if white noise is present together with the gliding tone at the input to the filter, the best analysis is still obtained by using the value of k that yields the sharpest response. The measure that will be adopted for the detectability of the response in the presence of noise is the peak signal-to-noise ratio at the output, which may be defined thus:

$$\sigma = \begin{bmatrix}\text{Peak signal output power, in absence}\\ \text{of noise}\end{bmatrix} \div \begin{bmatrix}\text{Mean noise output power, in absence}\\ \text{of signal}\end{bmatrix}$$

$$= \tfrac{1}{2} E^2_{max} / V_n^2, \text{ say} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (74)$$

Here the output voltages are supposed to be applied to some resistive load, and the power referred to is that dissipated in the load. The factor $\frac{1}{2}$ appears in equation (74), because, at the output from the filter, the signal and the noise are both quasi-sinusoidal oscillations, so that they must be compared on the same footing. Accordingly, when comparing it with the mean noise power, the peak signal power must be taken as the average of the signal power over a complete cycle of oscillation at the maximum of the response, rather than as

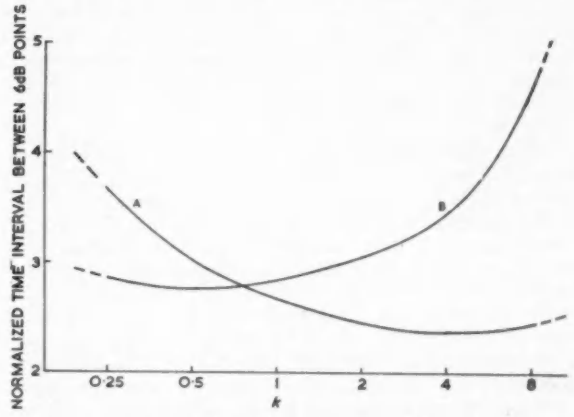


Fig. 8. Dependence of the widths of the response of the parameter k
Curve A. Simple tuned circuit
Curve B. Time-symmetric filter

the instantaneous power at the peak of a cycle; for a sinusoidal oscillation, the average power is half the instantaneous peak power.

The way in which σ varies with the filter bandwidth W is deduced as follows:—

If the frequency of the gliding tone varies smoothly over a wide range, then clearly its energy spectrum must be more or less level over any relatively narrow part of this range. Therefore the amount of energy which the filter accepts from the signal at its input is proportional to its bandwidth W. At its output, this same energy forms a response that has a height E_{max} and is spread over a certain time, δt say. Thus it follows from the law of conservation of energy that

$$E^2_{max}\, \delta t \propto W \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (75)$$

If the noise at the input to the filter has a level power spectrum, then the total noise power at the output, in the absence of signal, is also proportional to the bandwidth, i.e.:

$$V_n^2 \propto W \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (76)$$

Hence it appears that

$$\sigma \propto 1/\delta t \quad \ldots\ldots\ldots\ldots\ldots \quad (77)$$

so the adjustment for sharpest response also yields the highest signal-to-noise ratio. This conclusion is approximate only, since the form of the response as well as its width

* *From a slightly different criterion of sharpness, Barber and Ursell concluded that the value $k = 3{\cdot}1$ was optimum for the simple tuned circuit.*

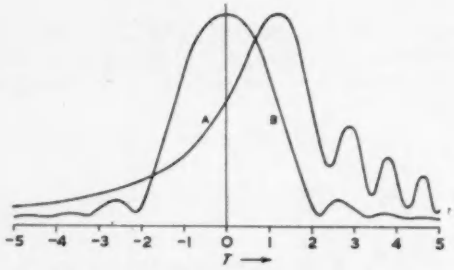


Fig. 9. Comparison of the theoretical optimum responses
Curve A. Simple tuned circuit ($k = 4$)
Curve B. Time-symmetric filter ($k = \frac{1}{4}$)

changes when k is altered, with the result that the proportionality (75) is inexact.

The optimum responses for the two types of filter are graphed in Fig. 9. The two responses have been plotted on the same scale of normalized time; also, they have been normalized to the same peak amplitude.

Experimental Results

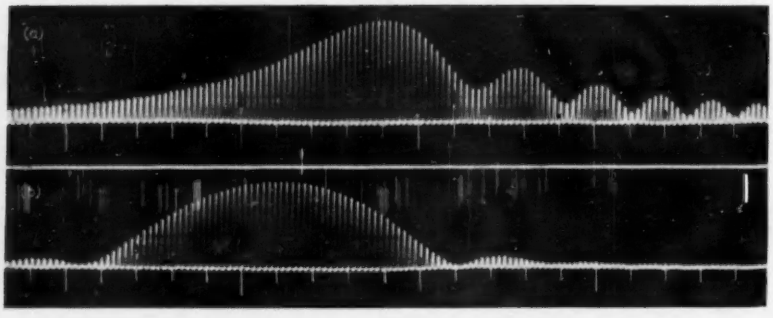
To provide a qualitative test of the analysis, the optimum responses of the simple tuned circuit and of the time-symmetric filter were recorded by cathode-ray oscillograph on moving film.

An artificial gliding tone, in the form of a recording on magnetic tape, was used in the test. The original tone was obtained from a beat-frequency oscillator, in which part of the tuning capacitance for the variable oscillator was supplied by a motor-driven variable capacitor, so that the frequency of oscillation was swept back and forth continuously. The frequency sweep was substantially linear in the middle of its range, the sweep rate being 500c/s^2 ± 5 per cent. The tone was recorded on one track of a multi-track tape recorder, while time marker pulses were recorded simultaneously on another track. The responses of the two filters were both obtained from the same recording, so that their relative timing could be established by aligning the marker pulses.

The magnetic tape recorder and the filter system have been described in Part 1. The bandwidth of the filter was set at 6·3c/s to give $k = 4$, and at 17·8c/s for $k = \frac{1}{4}$, while its resonant frequency was 600c/s in both cases. Before entering the oscillograph, the output from the filter was passed through a half-wave rectifier, but not smoothed, and then the time marker pulses were added to it, using a combined adding and switching circuit which suppressed the signal during the marker pulses[13]. In this way the oscillograms were arranged to show the envelope of the output as displacements of the trace in one direction, and the timing marks as displacements in the opposite direction, from a fixed baseline.

The oscillograms of the two optimum responses are given in Fig. 10. The small timing marks are spaced at intervals of 10msec, and the large marks at intervals of 50msec. The larger interval corresponds roughly to an interval of 2 in normalized time T. Though the observed and calculated responses have not been compared quantitatively, their general agreement appears satisfactory.

Fig. 10. Comparison of the observed optimum responses
(a) Simple tuned circuit ($k = 4$)
(b) Time-symmetric filter ($k = \frac{1}{4}$)



Discussion and Conclusions

On comparing the optimum responses of the two filters, it becomes clear that the time-symmetric filter is more useful than the simple tuned circuit in the analysis of gliding tones, for the following reasons:—

(*a*) Its response is symmetrical and centred on the moment of resonance, so that no correction need be applied to the observed time of maximum response. This is its main advantage.

(*b*) The subsidiary maxima are considerably reduced in amplitude. The first two such maxima, which are symmetrically disposed on either side of resonance, have amplitudes of only 13 per cent of the value at resonance. Hence there is less likelihood of confusion between subsidiary maxima and the responses produced by adjacent tones.

(*c*) The general level of the skirts of the response is lower, so that it should be possible to resolve gliding tones at closer spacing.

These remarks should be qualified by pointing out that the main maximum of the time-symmetric response is slightly the wider (c.f. Fig. 8), and that the effects at (*b*) and (*c*) are probably due more to the sharper cut-off of the time-symmetric filter, that is to say, its greater attenuation of frequencies well removed from resonance (c.f. Fig. 4 of Part 1), than to its freedom from phase-shifts, because similar improvements are obtained when the simple tuned circuit is replaced by two such circuits in cascade[14].

To conclude, the narrow-band time-symmetric filter is likely to prove itself useful in the analysis of gliding tones, whenever the highest accuracy of time measurement is called for, and the greater time required for this technique is not objectionable. The application envisaged originally was to the precise analysis of whistling atmospherics[15], but it might also be applicable to analysing the Doppler-shifted continuous-wave transmissions from the artificial earth satellites.

Acknowledgments

The authors wish to thank Mr. P. A. Field, Mr. W. L. Hatton and Dr. L. L. Campbell for their advice in the preparation of this article.

APPENDIX

THE SERIES-TUNED CIRCUIT

In the appendix to Part 1 it was shown how, starting from a series-tuned circuit, a filter can be simulated that has an overall impulse response somewhat resembling that of the time-symmetric filter described above; the envelope of the response is the same, but the oscillation within the envelope is a sine instead of a cosine wave, i.e.,

$$U(t) = U_0 \exp(-\pi W|t|) \sin(2\pi f_0 t)$$

(c.f. equation (43))

This overall impulse response is related to the impulse response $u(t)$ of the series-tuned circuit by the expression:

$$U(t) = \frac{U_0}{u_0}\left\{u(t) - u(-t)\right\} \quad \text{(c.f. equation (42))}$$

where $u(t)$ is given by

$$u(t) = \begin{cases} 0 & (t < 0) \\ u_0 \exp(-\pi W t)\sin(2\pi f_0 t) & (t \geqslant 0) \end{cases} \quad \text{(c.f. equation (39))}$$

Since this overall impulse response is so similar to the other, it is interesting to compare the gliding tone responses. Equation (42) shows that the gliding tone response for the present case can be obtained by evaluating the corresponding responses for the series-tuned circuit, first with the impulse response the normal way round and secondly with it reversed, then subtracting the two results, and finally multiplying by the amplitude factor U_0/u_0 in the same general way as before.

Barber and Ursell's analysis (which was, indeed, developed originally for the series-tuned circuit) gives the gliding tone response as

$$V_{out}(t) = V_0 u_0 [A(t)\sin\phi(t) - B(t)\cos\phi(t)] \ldots (78)$$

where the amplitude factors $A(y)$, $B(t)$ retain their previous meaning (equation (55)), and the filter has its normal impulse response. The envelope of V_{out} is

$$E(t) = V_0 u_0 \left[\left\{A(t)\right\}^2 + \left\{B(t)\right\}^2\right]^{\frac{1}{2}} \quad \text{(c.f. equation (56))}$$

which is the same as for the parallel-tuned circuit.

If the impulse response of the filter were reversed somehow, the gliding tone response would be

$$V_{out}(t) = V_0 u_0[-A(-t)\sin\phi(t) + B(-t)\cos\phi(t)] \ldots (79)$$

On combining the results of equation (78) and (79), the overall gliding tone response of the simulated filter is found to be

$$V_{out}(t) = V_0 U_0 [\left\{A(t) + A(-t)\right\}\sin\phi(t) - \left\{B(t) + B(-t)\right\}\cos\phi(t)] \quad \ldots . (80)$$

The difference between this response and that of the time-symmetric filter (equation (67)) lies only in the phase of the oscillatory terms. Their envelopes are the same, viz:—

$$E(t) = V_0 U_0 \left[\left\{A(t) + A(-t)\right\}^2 + \left\{B(t) + B(-t)\right\}^2\right]^{\frac{1}{2}}$$
(c.f. equation (68))

so the rest of the theory proceeds as before. Evidently this filter is equally applicable to the analysis of gliding tones.

Errata

Equation (39), Part 1, should read:

$$U(t) = \begin{cases} 0 & (t < 0) \\ U_0 \exp(-\pi W t)\sin(2\pi f_0 t) & (t \geqslant 0) \end{cases}$$

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International Colloquium on Nuclear Electronics

Electronic techniques have been applied to most, if not all, fields of scientific endeavour. In some of these, new techniques have had to be devised to meet the particular problems encountered and this, combined with the general growth of activity in electronics, has led to the establishment of separate specialized fields of electronics.

The emergence of Nuclear Electronics as a field on its own was marked by an International Colloquium on the subject held in Paris from 16 to 20 September. The Colloquium was organized, most admirably, by the Société des Radioelectriciens and was attended by some 500 delegates. Something in the region of 80 short papers were presented in nine sessions.

The first two sessions were concerned mainly with devices for the conversion of the nuclear radiation to electrical signals. The scintillation method is receiving a great deal of attention at present and a number of papers were presented giving details of work carried out with a view to understanding the basic processes in scintillators and in evaluating the performance of a variety of existing scintillators. Recent work on photomultipliers, particularly on the reduction of transit time spread was described. A paper was read on a gas Cerenkov counter and details were given of several gamma ray spectrometers.

One session was devoted to fast pulse techniques. At the present time, an electronic circuit is regarded as fast if the pulse rise-time is less than, say, 10 nanoseconds. A number of papers dealing with the generation, handling and measurement of such pulses were given. The application of slow pulse techniques to the nuclear field and particularly to the design of pulse height analysers was dealt with at another session entitled "Classical Electronics".

Several pulse height analysers were also described at the session on Data Processing. These reflected the growing interest in two and three-dimensional analysers. A relatively simple apparatus, in which two coincident pulses from separate counters are applied directly to the X and Y plates of a cathode-ray tube, has been found to be very useful as an instrument for chemical analysis. (1 part in 10^7 of manganese in rats liver has been detected). A 96×32 channel XY analyser with magnetic drum storage and a $256 \times 256 \times 256$ channel XYZ analyser with a 25 channel magnetic tape store were also described.

Several papers on the processing and presentation of reactor data were read and two sessions were devoted to reactor instrumentation and simulation. Health monitoring and radioactivity survey instruments were the subject of another session.

One session was devoted to the use of transistors in nuclear electronic systems. The trend in this direction could be seen from the papers presented in other sessions and it was held to be highly desirable particularly from the aspect of reliability.

Crane-Approach Warning System

In situations where two or more overhead travelling cranes are operated on the same track there is constant danger of collision, because the crane driver must concentrate on his load and the signals of his slinger rather than on the movement of neighbouring cranes. To eliminate this danger a new electronic equipment has been developed (under the auspices of the British Iron and Steel Federation) by The British Thomson-Houston Co. Ltd. and an installation has been undergoing extensive trials at the Redbourn, Scunthorpe, iron and steelworks of Richard Thomas and Baldwins Ltd.

The BTH system is based fundamentally on the principle of the echo sounder. An oscillator circuit generates short electrical pulses at regular intervals which are emitted in the form of very high frequency sound by a loudspeaker fitted on the crane. The sound pulses are reflected by a special trihedral reflector fitted on the neighbouring crane and the echo is picked up by a microphone mounted alongside the sound source. The microphone signal is then amplified and fed to relays which may operate audible alarm or visual indicating circuits in the driver's cab, or may be used to initiate braking of the crane.

Automatic warning of approach can thus be given to one or more cranes operating on the same track, or to cranes operating at different levels.

The equipment can be adjusted to operate up to a distance of 60ft from the reflector. The oscillating frequency is 11kc/s and the time taken for a return echo to operate the protective system is 2msec/ft. Selective circuits are designed to make the alarm system unresponsive to any other signals than those of the genuine echo.

Design Curves for Simple Filters

By D. J. H. Maclean*

A series of charts is presented giving the normalized element values as a function of the allowable pass band variation for Butterworth or Chebyshev behaviour of the insertion loss. The values relate to LC filters of constant-k configuration working between certain resistive terminations, and can be read to an accuracy of 1 per cent. The charts are given for low-pass filters having from two to seven branches, and can be extended to high-pass, band-pass or band-stop filters by the well-known frequency transformations.

In the case of an odd number of branches, a simple procedure allows one to obtain the element values for a filter working between general finite and non-zero resistances from the element values given in the charts.

Graphical data is presented to show the number of branches required to meet a given pass band variation and stop band attenuation.

The minimum unloaded-Q required to realize the desired response shape is given for the three cases when the number of branches is odd.

Some examples illustrate the use of the charts.

THE article only considers a particularly simple structure of inductors and capacitors, namely single element series or shunt branches, connected alternately series-shunt-series and so on. This configuration, the ladder configuration, is, however, of great practical interest. The form of the low-pass ladder network is readily derived by considering the desired behaviour, namely no transmission loss at low frequencies and high loss beyond some arbitrary frequency. The basic low-pass structure is thus series inductors and

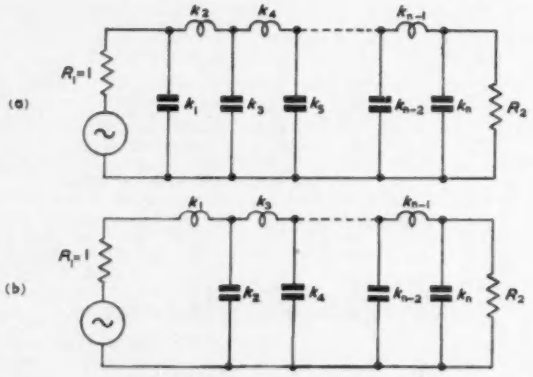


Fig. 1. The basic low-pass structure

shunt capacitors connected alternately (see Fig. 1). Such a network constructed from random elements of the appropriate kind would show some sort of low-pass behaviour. However, one is interested in a specific, predictable and realizable behaviour so that there must be definite relationships between the element values. To establish these, one must be given further information. Since only the amplitude-frequency characteristic is of interest here, the relevant information is the allowable variation of transmission in the pass band, the required minimum loss in the stop band, the frequency interval between the pass and stop band and finally the values of the terminating resistances. The primary design parameters are thus; allowable pass band variation, minimum stop band loss, frequency transition interval. Usually the pass band variation and the frequency interval are fixed, but the stop band specification represents a lower limit. If this is the case, two of the parameters can be combined to give one secondary parameter, the number of elements required. The approximation to constant transmission in the pass band can be done in several ways, two of which are normally used. The first historically is the Butterworth, or maximally flat, and the second the Chebyshev, or equal ripple approximation, both are illustrated in Fig. 2.

In order to give design data in a usable form graphical presentation is desirable, but for this to be practicable some further restrictions are required. The restriction imposed here is one applying to the ratio of the terminations, and

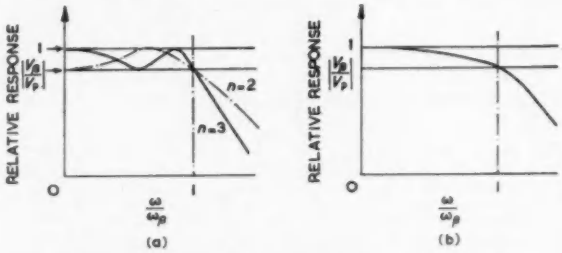


Fig. 2. The Butterworth and Chebysher approximations

this will be considered later. Design data in graphical form has long been available for filters based on image parameter theories. Such information of itself does not enable an approximation to constant pass band transmission to be obtained without further extensive computation. Curves giving the element values as a function of the pass band insertion loss variation were given by Atiya[1], but not in convenient form. The present curves are offered as a direct method for the design of a restricted class of filter and terminations. The class of filters is the simple *LC* ladder with all its infinite loss points at infinite frequency. The terminations are restricted to be equal in the case of Butterworth response filters and are normalized to 1. For the Chebyshev approximation, the ratio of the terminations depends upon the number of branches, being unity if the number of branches is odd, and a definite, non-unity ratio for an even number of branches.

If there are an odd number of branches, the normalized element values given in the charts, which are for equal terminations, can readily be converted to the case of unequal terminations. The element values from the charts yield a symmetrical network which is then bisected along its plane of symmetry, giving two networks having mirror-image symmetry. This is an example of Bartlett's Bisection

* *Barr & Stroud Ltd.*

Theorem. The branch impedances of the right-hand network are then multiplied by the ratio R_2/R_1. The two networks are then rejoined yielding a filter having the same relative insertion loss, but working between resistances R_1, R_2 where $R_1 = R_2$. The insertion loss of the unsymmetrical filter is $\frac{1}{2}(1 + R_2/R_1)$ times that of the original symmetric network. Note that both R_1 and R_2 must be finite and non-zero. An illustrative example is given.

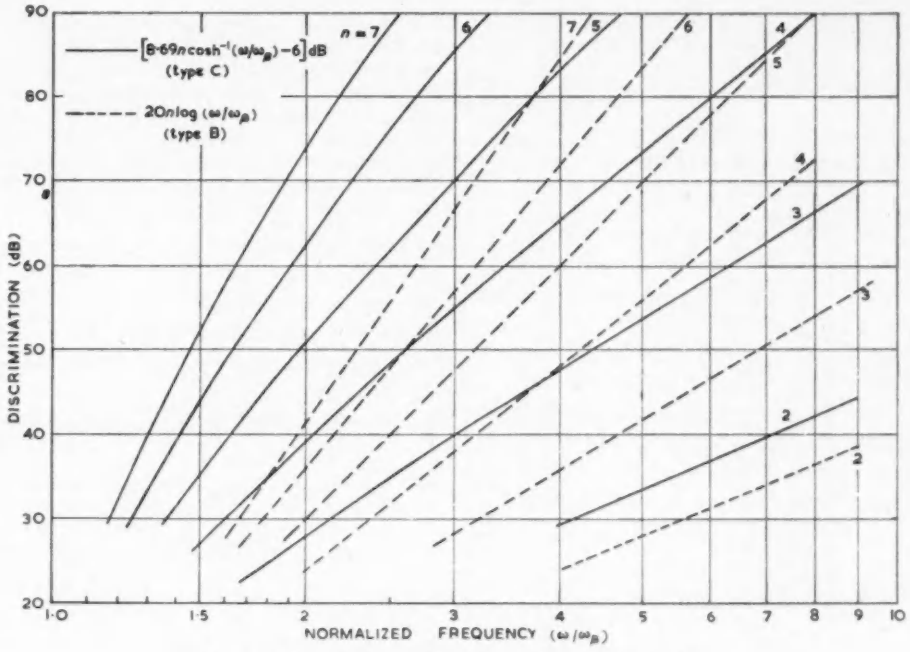


Chart 1. Discrimination/normalized frequency for different values of n

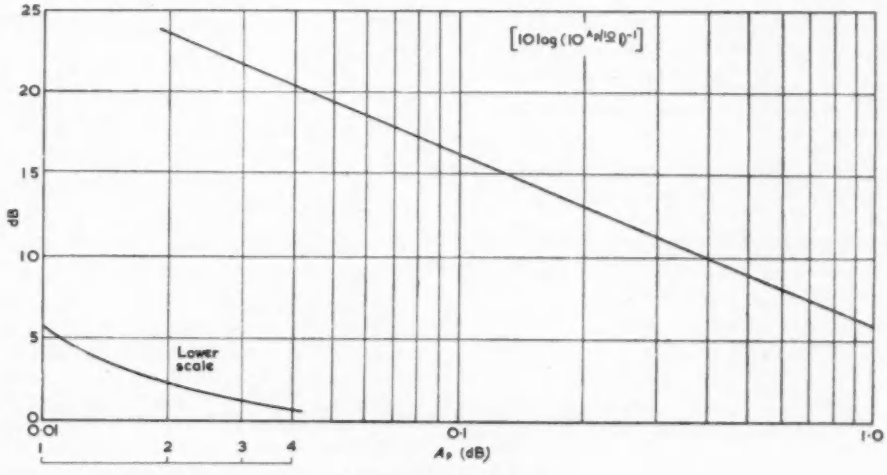


Chart 2. Pass band factor

The Charts

Fig. 1 illustrates the types of filters under consideration, i.e., simple low-pass ladder filters. Fig. 2 shows the two types of response and the symbols used in the work.

The first two charts enable one to choose a suitable number of branches n from a given specification of the band-pass variation A_p and the minimum discrimination A_m. Chart 1 must be corrected for the 'pass band factor' shown in Chart 2. The smaller the permissible variation in the pass band the lower is A_m for a given frequency and n.

The next set of Charts 3 to 8 give the element values as a function of A_p and of n for type B response. Charts 9 to 14 give the same information to provide type C response. The curves were obtained by extensive computation from the formulae shown in the appendix and the

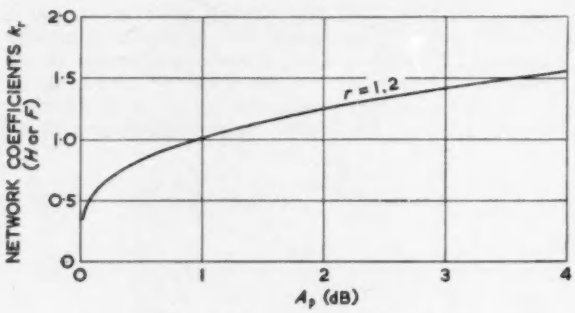


Chart 3. Element values for type B response. $n=2$

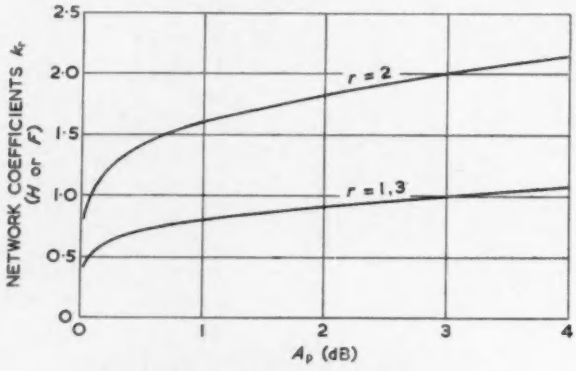


Chart 4. Element values for type B response. $n=3$

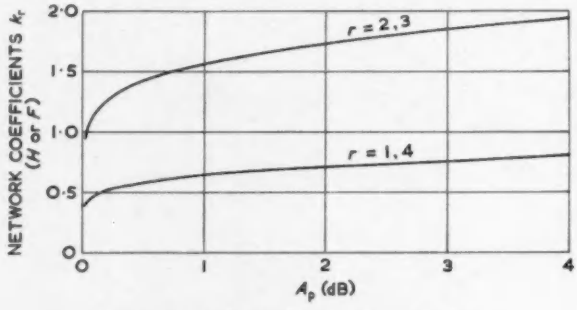


Chart 5. Element values for type B response. $n=4$

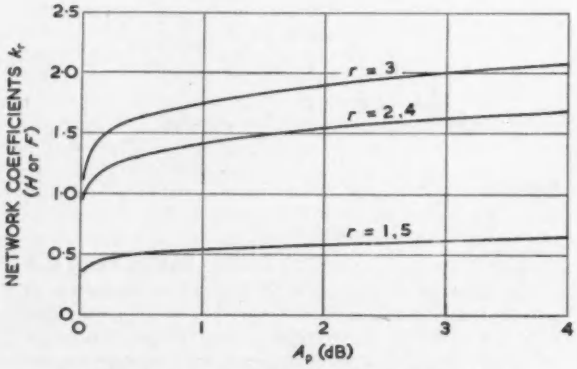


Chart 6. Element values for type B response. $n=5$

working was done to an accuracy of about 0·3 per cent. Where possible the results have been checked against other sources, e.g. Mole[2] and Green[3]. It should be noted that when n is even and type C response is required, the shunt branch is on the side of larger R which in terms of Fig. 2 is R_2. It is, however, immaterial which side of the network is taken as the generator end. The value of R_2 for $R_1 = 1$ is given in Chart 15.

So far, ideal reactive elements have been assumed; in practice the Q of capacitors and inductors, particularly the latter, imposes a limitation on the performance which can be obtained. Following Dishal[4] one can express the limitation in terms of the 'minimum unloaded Q' that is, the lowest Q of the elements from which the filter will be constructed. If the available elements have an unloaded Q which is lower than the minimum value, the particular requirements cannot be met. The minimum Q for $n =$

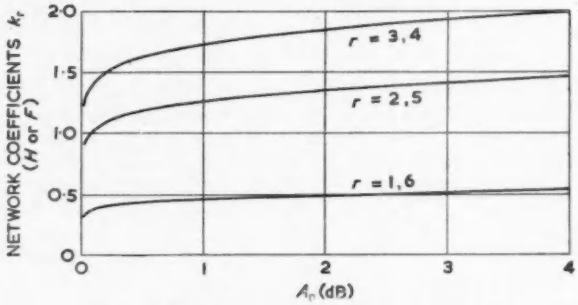


Chart 7. Element values for type B response. $n=6$

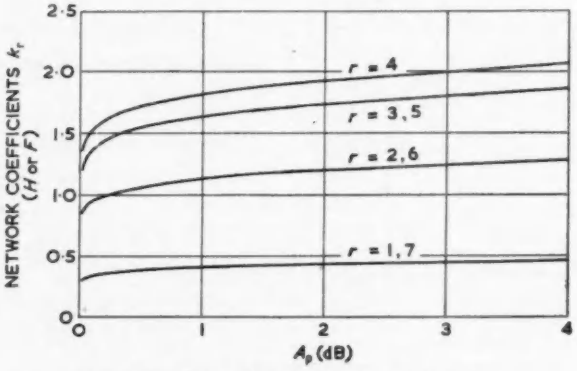


Chart 8. Element values for type B response. $n=7$

3, 5, 7 and for both types of behaviour is shown in Charts 16, 17. It will be observed that type C behaviour imposes a much more stringent requirement on the minimum Q than does type B performance. These low-pass values can be readily converted to the band-pass or band-stop cases by multiplying by the factor $2/w$ where w is the fractional bandwidth.

To convert from the normalized element values found in the charts, one uses the formulae below:

$$L = kR/\omega_\beta,\ C = k/R\omega_\beta$$

Where k is the normalized inductance in henries or capacitance in farads. For conversion from low-pass values above one utilizes the relevant frequency transformation.

Example 1

A low-pass filter is to be designed to meet the following

specification:

ATTENUATION	FREQUENCY INTERVAL	NORMALIZED INTERVAL
< 0·2dB	$0 \leqslant f \leqslant 1\,000$ c/s	$0 \leqslant \omega/\omega_\beta \leqslant 1$
> 36dB	$2\,000 \leqslant f \leqslant \infty$	$2 \leqslant \omega/\omega_\beta \leqslant \infty$

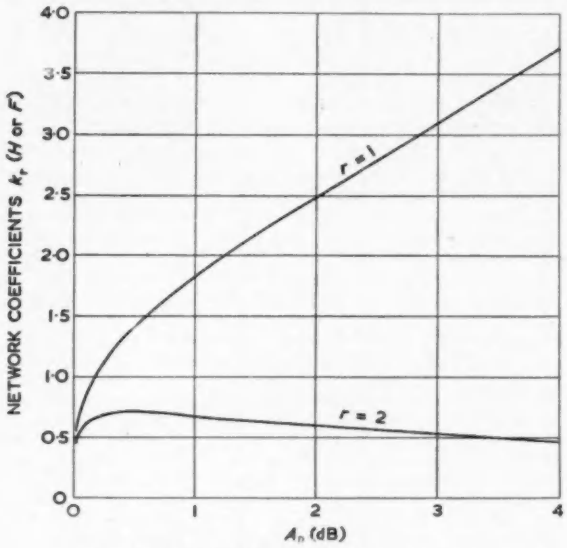


Chart 9. Element values for type *C* response. $n = 2$

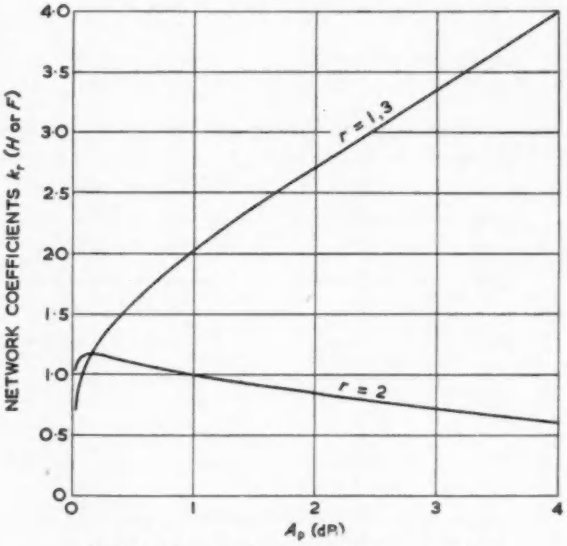


Chart 10. Element values for type *C* response. $n = 3$

The filter is to work between equal resistive terminations of value 1 000Ω. The available inductor Q is 100 and that of the capacitors comparatively infinite. A simple series L, shunt C ladder is required.

DESIGN PROCEDURE

(1) From Chart 2, the pass band factor for $A_p = 0{\cdot}2$dB is 13·2dB.

(2) The correction factor of 13·2dB is to be subtracted from all curves, alternatively the ordinate scale is suitably modified. At a normalized frequency of 2 one sees that the modified requirement of 36 + 13·2 = 49·2dB could be met with $n = 5$ and type *C* behaviour. The corresponding number of elements for type *B* response is evidently $n = 9$.

(3) Since the specification includes a figure for Q, one must check that the above choice is suitable. From Chart 17 one sees that $Q_{min} = 7$ so that for $Q = 100$ the response will be little affected by finite Q. It might well be remarked that were a narrow band band-pass filter under consideration, the minimum fractional bandwidth w is given by:

$$(2/w)\,7 = 100$$

or $w = 0{\cdot}14$.

(4) The element values are obtained from Chart 12 as:

$$k_1 = k_5 = 1{\cdot}347$$
$$k_2 = k_4 = 1{\cdot}336$$
$$k_3 = 2{\cdot}219$$

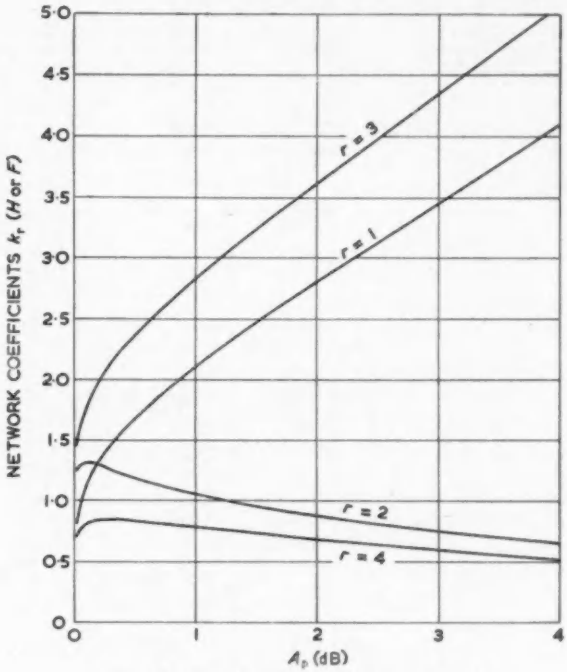


Chart 11. Element values for type *C* response. $n = 4$

(5) From the normalized values, the actual element values are obtained as follows:

$$C_1 = C_5 = 1{\cdot}347/2\pi 10^6 = 0{\cdot}224\mu\text{F}$$
$$L_2 = L_4 = 1{\cdot}336/2\pi = 0{\cdot}212\text{H}$$
$$C_3 = 2{\cdot}219/2\pi 10^6 = 0{\cdot}353\mu\text{F}$$

The dual network ($L_1 = L_5$, $C_2 = C_4$, L_3) is obtained similarly.

EXAMPLE 2

A filter is required to meet the same specification as that of example (1) but is to operate between resistive terminations of $R_1 = 1\,000\Omega$ and $R_2 = 3\,000\Omega$.

One can commence immediately with the normalized element values (or with the final element values) given in step (4) above. The stages of the transformation from symmetric network to one terminated in 1Ω and 3Ω are illustrated in Fig. 3. The network (b) shows explicity the mirror image component structures. Network (c) is obtained by multiplying all the branch impedances of the right-hand

structure by the ratio $R_2/R_1 = 3$, i.e. each inductance is multiplied by 3 and each capacitance by 1/3. The original left-hand section and the modified right-hand section are recombined to give a normalized network having the following element values.

$k_1 = 1{\cdot}347$, $k_2 = 1{\cdot}336$, $k_3 = 1{\cdot}48$, $k_4 = 4{\cdot}008$, $k_5 = 0{\cdot}449$

The actual element values are obtained from these in a precisely similar fashion to that of example (1).

The flat loss for this filter will be $0{\cdot}5\ (1 + 3) = 2$ times that of the symmetric filter, which has a minimum insertion loss of 0dB, so that the asymmetric filter has a minimum insertion loss of 6dB.

EXAMPLE 3

A band-pass filter is required which meets the specification:

ATTENUATION	CENTRE FREQUENCY	FREQUENCY INTERVALS
< 0·5dB	500kc/s	475 ⩽ f ⩽ 525kc/s
⩾ 50dB		450 ⩽ f ⩾ 550kc/s

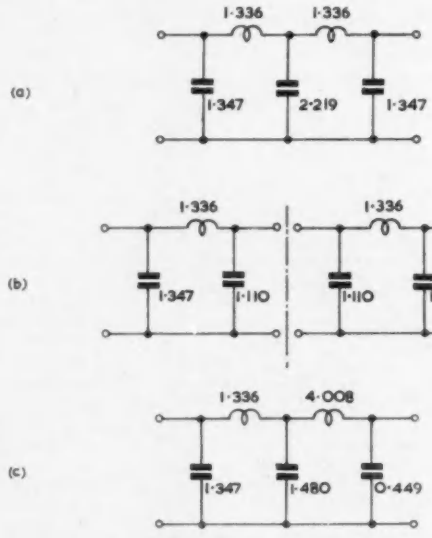


Fig. 3. Stages in the transformation from a symmetric network to one terminated in 1Ω and 3Ω

The available inductor Q at 500kc/s is 250.

A geometrically symmetrical response is desired so that the design can be based on a low-pass prototype network. This prototype network is required to meet the following specification:

ATTENUATION	FREQUENCY INTERVAL	NORMALIZED INTERVAL
< 0·5dB	0 ⩽ f ⩽ 50kc/s	0 ⩽ ω/ω_β ⩽ 1
⩾ 50dB	100 ⩽ f ⩽ ∞	2 ⩽ ω/ω_β < ∞

The equivalent Q is found as follows:

$$Q_e = (w/2)Q$$
$$= 50/1\,000 \times 250$$
$$= 12{\cdot}5$$

The computation can be carried out as shown below.

(1) *Pass band factor*

From Chart 2, the factor for $A_p = 0{\cdot}5$dB is 9dB.

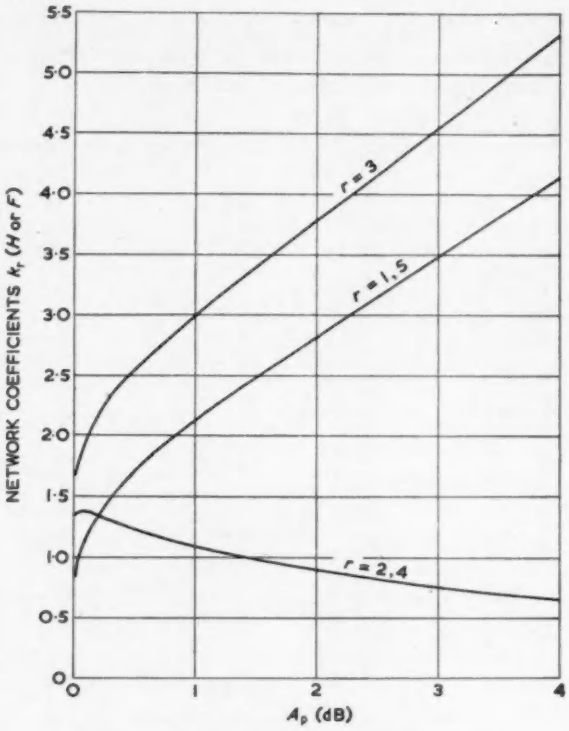
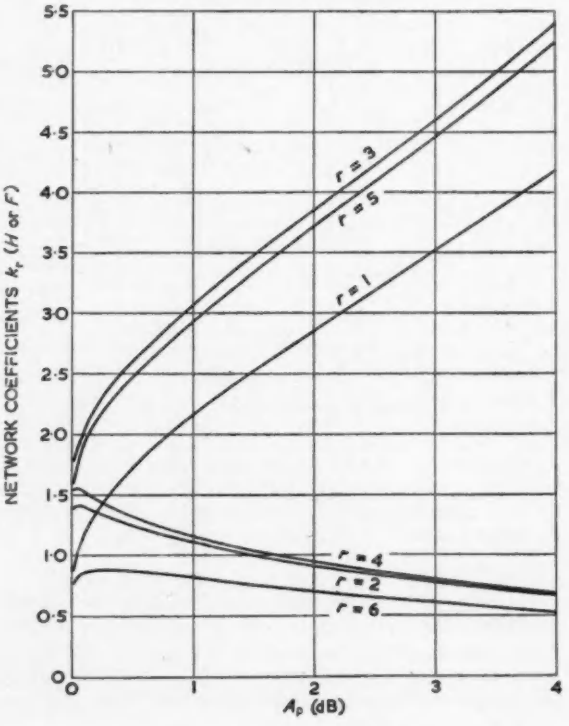


Chart 12. Element values for type C response. $n = 5$

Chart 13. Element values for type C response. $n = 6$



(2) *Estimate of number of elements required*

The figure for the discrimination to be used with Chart 1 is obviously 59dB. From the chart one sees that with $\omega/\omega_\beta = 2$, the required value for n is 6 if type C behaviour is chosen; it is evident that many more elements would be necessary to obtain type B behaviour. As a band-pass network is the ultimate object, the fact that n is even is not of importance.

(3) *Check on required Q minimum*

Chart 17 shows that for $A_p = 0{\cdot}5$dB, the minimum unloaded Q is approximately 13, thus the desired behaviour cannot be realized as the design stands. It is evident, however, that if A_p is reduced the value of Q minimum is decreased. A suitable choice would be to alter A_p to 0·2dB. This alteration means that steps (1) and (2) must be

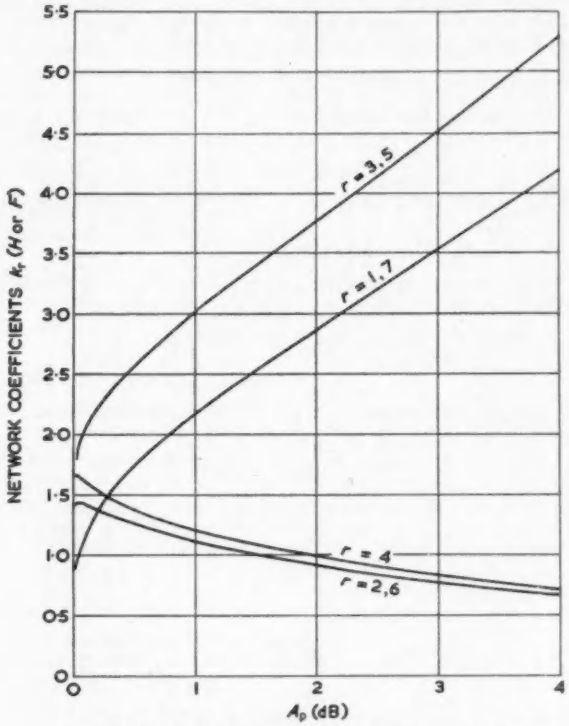


Chart 14. Element values for type *C* response. $n = 7$

repeated; the results are then:

(a) The pass band factor = 13·2dB (Chart 2).

(b) The discrimination of 63·2dB is just about met for $n = 6$, and is sufficiently close (Chart 1).

(c) The minimum Q is now 10 (Chart 17).

(4) *Element values*

From Chart 13, one finds:

$k_1 = 1{\cdot}350$ $\quad k_2 = 1{\cdot}360$

$k_3 = 2{\cdot}230$ $\quad k_4 = 1{\cdot}462$

$k_5 = 2{\cdot}091$ $\quad k_6 = 0{\cdot}880$

If one chooses a network with series input (see Fig. 1(b)), the k's with odd subscripts correspond to inductance values and those with even subscripts to capacitance values.

(5) *The prototype low-pass filter*

The low-pass network from which the band-pass filter

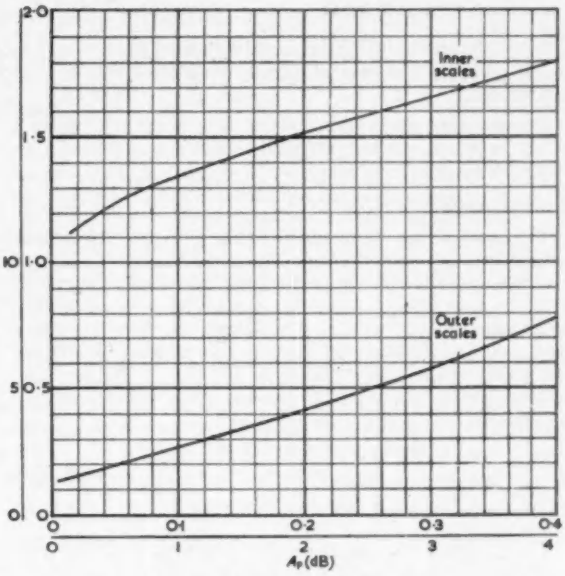


Chart 15. The value of R_2 for $R_1 = 1$

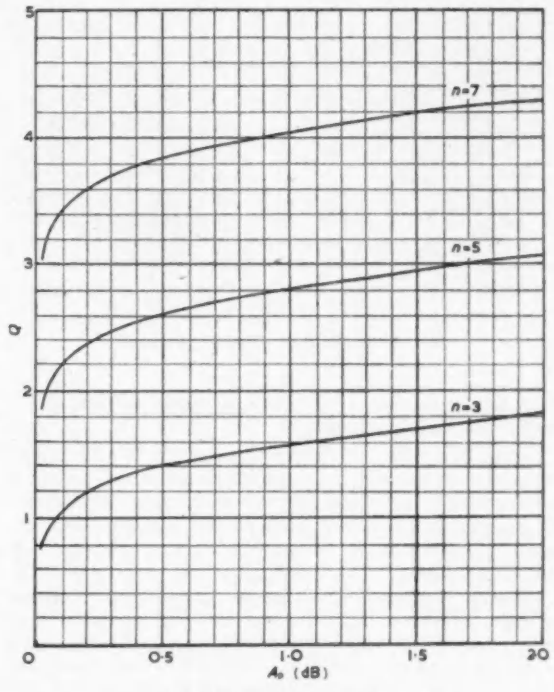


Chart 16. Minimum Q for type *B* response

will be derived is readily obtained from the normalized values found in step (4). The values are found from the formulae:

$L_i = (k_i R/\omega_\beta)$ H, $i = 1, 3, 5$; $C_j = (k_j/R\omega_\beta)$ F, $j = 2, 4, 6$,

which yield:

$L_1 = 4{\cdot}30$mH, $\quad C_2 = 4\,330$pF

$$L_3 = 7{\cdot}10\text{mH}, \qquad C_4 = 4\,660\text{pF}$$
$$L_5 = 6{\cdot}66\text{mH}, \qquad C_6 = 2\,803\text{pF}$$

for $R_1 = 1\text{k}\Omega$, $R_2 = 1{\cdot}52\text{k}\Omega$ (from Chart 15), and $\omega_\beta = 2\pi \cdot 50 \cdot 10^3$.

Summarizing the progress so far, a low-pass filter having a bandwidth of 50kc/s to 0·2dB points and 100kc/s to 50dB points has been designed.

(6) *The band-pass filter*

The method for obtaining this from the prototype low-pass filter is very simple. The mid-frequency has to be translated from zero to the geometric mean of 475kc/s and 525kc/s. This is accomplished by resonating each inductor with a series capacitor, and each capacitor with a shunt inductor, all circuits being tuned to 500kc/s (very closely the geometric mean frequency). The required element values are quickly obtained from the *LC*-product at 500kc/s, that is from the value of $1/\omega_r^2$.

$$LC\text{-product} = 101{\cdot}32\text{mH} \times \text{pF}.$$

$L_1 = 4{\cdot}30\text{mH}$ ($C_1 = 23{\cdot}6\text{pF}$); $C_2 = 4\,330\text{pF}$ ($L_2 = 23{\cdot}4\mu\text{H}$)
$L_3 = 7{\cdot}10\text{mH}$ ($C_3 = 14{\cdot}28\text{pF}$); $C_4 = 4\,660\text{pF}$ ($L_4 = 21{\cdot}8\mu\text{H}$)
$L_5 = 6{\cdot}66\text{mH}$ ($C_5 = 15{\cdot}24\text{pF}$) ; $C_6 = 2\,803\text{pF}$ ($L_6 = 36{\cdot}2\mu\text{H}$)

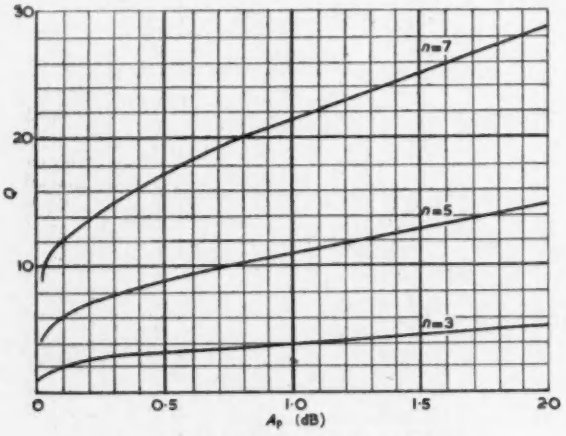


Chart 17. Minimum *Q* for type *C* response

(7) *Some remarks of a practical nature on the above design may be of interest*

In the first place, since the actual Q is by no means comparatively infinite, the measured response will not show a flat top of 0·2dB ripple but will droop near the edges of the pass-band. To a certain extent, this could be compensated by modifying the terminations. There will also be a loss at mid-band due to finite element Q.

Secondly, band-pass filters offer a great deal of freedom in their realization, and this can be used to modify the element values in some convenient manner for example. In addition, transformer action can be incorporated, and thus one could use equal terminations if so desired.

The coils used in the above design would require to have a fairly low self-capacitance, but ferrite pot cores would probably be satisfactory.

As a rough guide to component tolerances, a figure of ±1 per cent on both inductors and capacitors is reasonable. and perhaps ±0·2 per cent on the resonant frequency.

Acknowledgment

The author wishes to thank the directors of Barr & Stroud Ltd for permission to publish this article.

Appendix

Stop Band Attenuation, Type B Response

The response of this type of filter is given by the equation:

$$|V_p/V|^2 = 1 + \left\{ |V_p/V_\beta|^2 - 1 \right\} (\omega/\omega_\beta)^{2n}$$

When the second member on the right-hand side greatly exceeds unity, which will be the case in the stop band, one can write:

$$|V_p/V|^2 \simeq \left\{ |V_p/V_\beta|^2 - 1 \right\}^{1/2} (\omega/\omega_\beta)^n$$

whence:

$$20 \log |V_p/V| = 10 \log \left\{ |V_p/V_\beta|^2 - 1 \right\} + 20\, n \log\, (\omega/\omega_\beta)$$

The first member on the right-hand side is the 'pass-band factor' given in Chart 2. The remaining equation when plotted on log-linear paper reduces to straight lines of slope n. The results are plotted on Chart 2.

Stop Band Attenuation. Type C Response

In this case, the response is given by the equation:

$$|V_p/V|^2 = 1 + \left\{ |V_p/V_\beta|^2 - 1 \right\} [T_n(\omega/\omega_\beta)]^2$$

In the stop band, the second member greatly exceeds unity, and the appropriate form of the Chebyshev function $T_n\,(\omega/\omega_\beta)$ is:

$$\cosh\,(n \cosh^{-1} \omega/\omega_\beta)$$

Thus, taking the exponential approximation to the cosh function and expressing the results in dB, one finds:

$$20 \log |V_p/V| = \left\{ 8{\cdot}68\, n\, [\cosh^{-1}(\omega/\omega_\beta)] - 6 \right\} + 10 \log \left\{ |V_p/V_\beta|^2 - 1 \right\}, \text{dB}$$

As before, the second term is the 'pass-band factor' given in Chart 2. The remaining term is plotted in Chart 1.

The formulae used in the preparation of the curves giving the element values for type *C* performance are due to Orchard[5]. His notation has been slightly modified. The formulae used in computing the values for type *B* behaviour are based on Atiya's article[1].

Type B Response

$$R_1 = R_2 = 1 \text{ for all } n$$
$$k_r = 2(10^{A_p/10} - 1)^{1/(2n)} \sin\,(2r - 1)\,\pi/2n$$

Type C Response

$$R_1 = 1 \text{ for all } n$$
$$k_1 = (2a_1/\gamma)$$
$$k_r k_{r-1} = \frac{4a_r a_{r-1}}{b_{r-1}}$$

$R_2 = 1$ for n odd; $R_2 = R_1 \coth^2 (nb/2)$ for n even

check: $k_1 = R_2 k_2$

where:

$$20 \log \coth nb = A_n \text{ dB}$$
$$= \sinh b$$
$$a_r = \sin\,(2r - 1)\,\pi/2n$$
$$b_r = \gamma^2 + \sin^2 (2r\pi/2n)$$

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An Electrical Multiplier Utilizing the Hall Effect in Indium Arsenide

By R. P. Chasmar* and E. Cohen*

The advantages pertaining to the use of semi-conducting indium arsenide as the basis of an electrical multiplier are discussed. A particular merit is the low value of the temperature coefficient of the Hall constant (0·06 per cent/°C) between −40°C and +100°C. The design of Hall plates is considered and certain figures of merit are proposed. Details are given of the construction and performance of a multiplier in which an indium arsenide Hall plate is mounted in the gap in a ferrite core. The harmonics produced in this multiplier at peak output were less than 1 per cent of the fundamental.

A DEVICE capable of the accurate multiplication of two electrical quantities could be of considerable importance to the electronic industry. Frequency changing utilizing the multiplication inherent in a non-linear valve characteristic dates back to very early days, but the more recent advent of the analogue computer has emphasized the need for a cheap and accurate device that can multiply without the production of unwanted frequency components. Various ingenious methods have been devised to meet this problem, but in order to obtain the necessary linearity and frequency response several valves and an associated number of diodes are required[1,2].

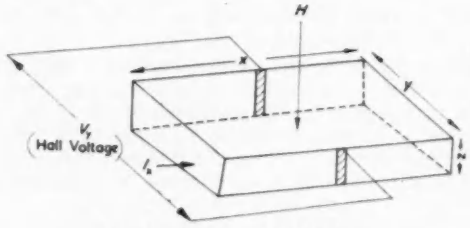


Fig. 1. Illustration of Hall effect

The possibility of using the Hall effect in a semiconductor as the basis of a multiplier has already been considered[3,4,5,6,7,8] since the Hall voltage measures the product of a current through the semiconductor specimen and a magnetic field which may itself be derived from a current through a magnet winding. This method offers several attractive features:—

(1) The multiplier is small, robust and relatively simple to manufacture as it consists primarily of a coil wound on some suitable ferromagnetic core with a semiconductor plate mounted in the gap.

(2) Linearity better than 1 per cent is obtainable and this is comparable with most electronic multipliers.

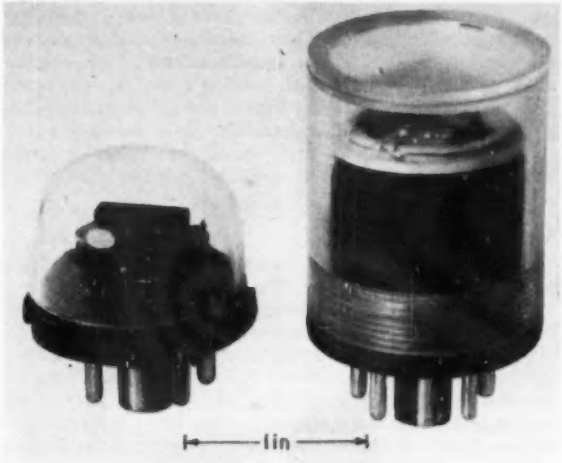
(3) The frequency response of the Hall effect is virtually unlimited. The multiplier will therefore work from d.c. to such frequencies as are determined by the electric and magnetic circuit arrangements. For very high frequencies an air-cored coil may be used.

The Hall Effect

Consider a slab of semiconductor (Fig. 1) placed at right-angles to a magnetic field H and carrying a current I_x. Due to the presence of the magnetic field the charge carriers are deflected to the edge of the slab and build up a potential V_y which may be detected between leads connected to the xz faces of the slab.

Equilibrium is reached when this potential rises to such a value that it just annuls the effect of the magnetic field and subsequent carriers are able to pass through the slab undeflected. If the electric fields in the x and y directions are E_x and E_y (in e.m.u.) then the balance of forces on the charge carriers can be expressed by

$$E_y \,.\, e = H \,.\, e \,.\, v.$$



Hall effect multiplier

e = electron charge

v = drift velocity of the electrons in the electric field. If the electron mobility is μ then

$$v = E_x \,.\, \mu$$

so that

$$E_y = H \,.\, \mu \,.\, E_x$$

and

$$V_y = yE_y = y \,.\, H \,.\, \mu \,.\, (r \,.\, I_x/x)$$

where r is the resistance of the slab in the x direction and can be expressed as

$$r = (1/\sigma) \,.\, x/(y \,.\, z) = 1/ne\mu \,.\, x/yz$$

where σ = specific conductivity of the semi-conductor

n = number of charge carriers per cubic centimetre in the semiconductor

Thus

$$V_y = (H \,.\, I_x)/z \,.\, 1/ne \text{ e.m.u.} \quad \ldots\ldots\ldots \quad (1)$$

V_y is known as the Hall potential, after its discoverer E. H. Hall, (1879) and the factor $(1/ne)$ is known as the Hall coefficient. The Hall coefficient is a constant of the material since it depends on the charge carrier concentration of the semiconductor.

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For normal metals, where n is of the order of 10^{22} electrons/cm³ the Hall coefficient has a very small value and the Hall effect is of little practical significance. Due to recent advances in semiconductor technology, advantage can be taken of the much lower electron concentrations in these materials and an increase of the order of 10^7 in the magnitude of the Hall coefficient obtained.

Hall Effect Multipliers

Open-Cirauit Operation

It is seen from equation (1) that the Hall potential is proportional to the product of the exciting current, the magnetic field and the Hall coefficient. Thus if the Hall plate and the coil producing the magnetic field are driven from constant current sources the Hall potential, measured across a load resistance high compared with the internal resistance of the Hall plate, will accurately represent the product. This accuracy will be maintained over a range of ambient temperatures only if the Hall coefficient of the material is independent of temperature.

The recently developed compound semiconductor, indium arsenide, appears to be particularly favourable since the temperature coefficient of the Hall effect between −40°C and +100°C is only 0·06 per cent/°C for material of Hall coefficient = 100cm³/C. The exceptionally high electron mobility (25 000cm²/V sec) and consequent high conductivity of the indium arsenide provide a low internal resistance suitable for operation into a grounded emitter transistor without appreciable departure from the open-circuit condition. Also it has been found that relatively crude polycrystalline material is adequate to make satisfactory multipliers.

Matched Operation

Circumstances may arise in which it is necessary to draw power from the Hall plate. The available power will be a maximum under the usual condition that the load resistance is equal to the internal resistance of the plate between the Hall probes. With this condition and with the plate driven from a constant current source it has been shown[9] that the conversion efficiency is proportional to the square of the carrier mobility in the material. Indium arsenide and indium antimonide have the distinction of possessing the highest electron mobility among known semiconductors. Typical values are given in Table 1.

The efficiency using indium arsenide is thus fifty times greater than with germanium and several hundred times greater than silicon. It should be noted, however, that the above-mentioned relationship between efficiency and mobility only holds for weak magnetic fields where the magneto-resistive effect is small. It is in fact never possible to obtain efficiencies greater than 17 per cent even with the highest mobilities and fields[10].

A disadvantage of the matched type of operation as compared with the open-circuit method is a certain loss of linearity. This is, of course, of prime importance in an electrical multiplier and open-circuit working is therefore to be recommended whenever possible. The non-linearity arises due to the dependence of the resistance of the semiconductor on the magnetic field. The resistance increases with increasing magnetic field and within certain limitations the increase is proportional to the square of the product of the magnetic field and carrier mobility. Thus as the field increases the Hall output departs more and more from matched conditions giving rise to a non-linear characteristic. This problem has been discussed by Kuhrt[4] who claims that by special construction of the Hall plate some compensation can be obtained and a linearity of 1 per cent achieved at an output of 80 per cent of the maximum available power.

TABLE 1

Electron mobility

MATERIAL	ELECTRON MOBILITY AT 20°C (cm²/V.sec)
Germanium	3 600
Silicon	1 300
Indium antimonide ..	65 000
Indium arsenide	25 000

Hall Plate Design Considerations

Consider the voltage output into an open-circuit of a Hall plate. The response of the plate to changes in exciting current or magnetic field may be represented by a quantity R such that from equation (1) expressed in practical units

$$R = V_H/H \,.\, I = R_H/t \,.\, 10^{-5}$$

where V_H = Hall voltage (mV)

I = plate current (mA)

H = magnetic field (kG)

R_H = Hall coefficient (cm³/C)

t = plate thickness (cm)

so that

$$\Delta V_H/\Delta I = R \,.\, H$$

and

$$\Delta V_H/\Delta H = R \,.\, I$$

R will be called the 'responsivity' of the plate given in units of mV/(mA . kG).

The maximum output obtainable from a Hall plate is limited by the maximum permissible heating effect produced in the plate by the exciting current. If the power dissipated in the plate by this means is P mW, the resistivity of the semiconductor ρ Ω-cm, the plate width w cm and plate area A mm², then using equation (1) it can be shown that

$$(V_H/H)\sqrt{(A/P)} = 3{\cdot}16 \,.\, 10^{-3} \,.\, R_H \,.\, w\sqrt{(2/t\rho)} \quad \ldots\ldots (2)$$

The quantity $V_H/H\sqrt{(A/P)}$ will be called the 'dissipation constant' of the plate and will be represented by the symbol M in units of mV/kG . √(mm²/mW). The value of M for a Hall plate corresponds to the Hall voltage output in millivolts obtained with a magnetic field of one kilogauss and a plate dissipation of 1mW/mm². This represents approximately the maximum allowable dissipation for a Hall plate mounted in free air.

It will be seen that both R and M will be increased by reducing the thickness of the plate. For devices such as multipliers with ferromagnetic cores a further advantage is obtained by using a thin plate in that the core gap is reduced permitting a greater magnetic field for a given coil current. Experience in this laboratory has shown that a practical limit to the minimum thickness of a Hall plate mounted on a rigid backing is about ·002in.

A further increase in M can be obtained by increasing the width of the plate (equation (2)). At the same time the length must also be increased in proportion to eliminate the undesirable effects due to the partial short-circuiting of the Hall voltage by the current electrodes[4]. The increased area of the Hall plate permits a greater power to be dissipated and a consequent increase in maximum output.

Construction of Multiplier

Hall effect multipliers can be constructed using air-cored coils where operation at high frequencies is desired. The output with such coils is small owing to the low value of the flux density obtained with normal values of coil current. For most analogue computer applications a frequency

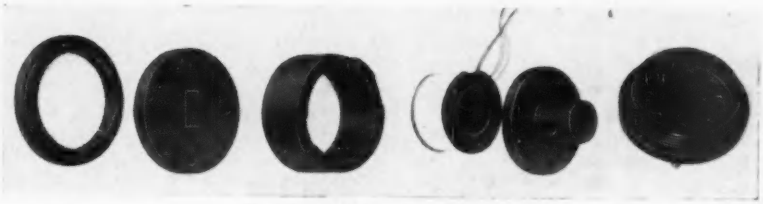

Fig. 2. Exploded view of multiplier

response ranging from d.c. to 100c/s is quite adequate and the use of a gapped ferromagnetic core to increase the flux is permissible.

The magnetic ferrite commonly known as Ferroxcube A.1 has some attractive features. The pot core assembly permits of a simple form of construction while the high resistivity (100Ω-cm) enables the Hall plate to be mounted directly on the magnetic material without the need for insulation which would increase the gap and reduce the flux. Also the initial permeability is greater and hysteresis losses less than silicon steel. On the other hand a disadvantage is the low saturation flux density ($B_{max} \simeq 3{\cdot}4$kG at

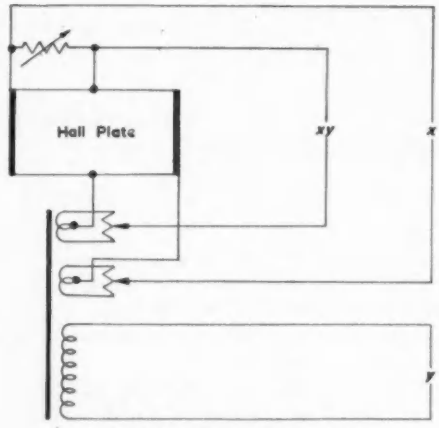

Fig. 3. Circuit of Hall effect multiplier

20°C). A multiplier utilizing a Ferroxcube pot core assembly is shown in exploded form in Fig. 2 and assembled multipliers are shown on page 661. The characteristics of a typical multiplier are given in Table 2.

The circuit diagram of the multiplier is given in Fig. 3.

With a.c. operation inductive coupling from the coil to the plate circuit and Hall circuit is inevitable owing to the finite size of the plate. This can be balanced out by the method suggested by Keister[6] in which additional small coils, shunted by very low resistance potentiometers are connected in the appropriate circuits. These are built into the multiplier and can be preset on test.

Exact positioning of the Hall probes on the specimen so that they lie on an equipotential in the absence of a magnetic field is extremely difficult. In order to eliminate any 'standing voltage' due to this cause a variable resistance is connected between one current connexion and one Hall connexion. By suitable adjustment of the resistance, the 'standing voltage' can be reduced to zero.

D.C. characteristics of this multiplier are given in Figs. 4 and 5. Fig. 4 shows the Hall output plotted against coil current for a plate current of 50mA; this relation is linear up to a coil current of 13mA. The departure from linearity at high coil currents is due to saturation of the Ferroxcube. Fig. 5 gives the dependence of Hall output on plate current at various values of field current; again the relationship is linear.

The field in the gap can be calculated as follows:—

$$\text{Flux density} = B = 4\pi/10 \cdot \frac{N\mu}{(L + (\mu - 1)g)}$$

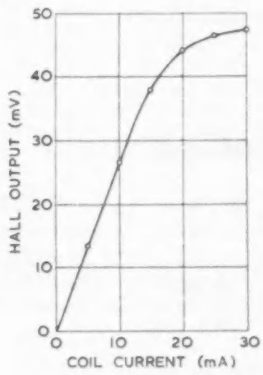

Fig. 4. Variation of Hall output with field current for indium arsenide multiplier

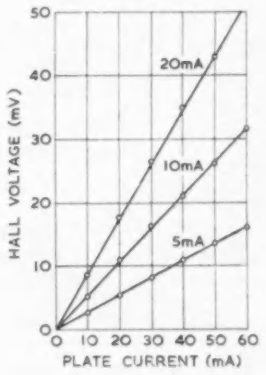

Fig. 5. Variation of multiplier output with plate current for three values of coil current

N = ampere-turns of field coil

L = length of iron circuit (cm)

g = gap (cm)

μ = permeability.

Taking $L \simeq 5$cm and $\mu \simeq 750$ then for a coil current of 13mA giving 33·5mV.

$$B = 2{\cdot}9\text{kG}$$

$$\text{Responsivity} = R = V_H/BI = \frac{33{\cdot}5}{2{\cdot}9 \times 50} = 0{\cdot}23$$

This is in reasonable agreement with the value of R calculated from the Hall constant and estimated plate thickness.

From the Hall output and measured resistances of the plate the dissipation constant for the multiplier is

$$M = 20(\text{mV/kG}) \sqrt{(\text{mm}^2/\text{mW})}.$$

Such a Hall plate mounted in contact with the pole piece could operate at a dissipation of 4(mW/mm²) which would correspond to a maximum Hall output of 150mV for a plate current of 220mA and coil current of 13mA.

The chief source of harmonic components in the Hall voltage with a.c. circulating in the core is the non-linear relationship between magnetizing field and magnetic induc-

TABLE 2

Characteristics of typical indium arsenide multiplier

Electrical conductivity	250Ω-cm^{-1}
Hall coefficient	100cm^3/C
Plate dimensions	0·8cm × 0·4cm × 0·005cm
Resistance—current connexions	5·4Ω
Resistance—Hall connexions ..	3·9Ω
Magnetic core gap	0·1mm
Coil winding data	3 000 turns 44 s.w.g.
Coil inductance	4·7H
Coil resistance	450Ω
Coil resonant frequency ..	6kc/s

tion. For a closed ring of Ferroxcube the shape of the *BH* loop is approximately rectangular, but if a gap is included in the ring the *BH* loop is sheared and ultimately degenerates into an approximately straight line for sufficiently large gaps. That this is so under d.c. excitation is seen in Fig. 4.

Measurements have been made of the harmonic content in the output of a Hall multiplier with d.c. supplied to the plate and a.c. to the coil at fundamental frequencies 80c/s and 300c/s. The harmonic content of the Hall output and of the source oscillator were measured using a Muirhead-Pamatrada wave analyser and the results compared. Unfortunately with the best oscillator available the harmonics present in the source signal were comparable with those introduced by the multiplier and so an accurate estimate of the distortion produced by the multiplier was not possible. The results at 80c/s indicated that where the peak value of the coil current did not exceed the limits of the straight portion of the d.c. characteristic (Fig. 4), the ratio of fundamental to second harmonic was about 40dB. At low values of coil current this rose to 60dB. An improvement of several decibels over these figures was obtained with a 300c/s fundamental.

Acknowledgments

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Multiplication by Semiconductors

By C. Hilsum*, B.Sc.,A.Inst.P.

Analogue multipliers can be made using either the Hall effect or magneto-resistance in semiconductors. The possible modes of operation are considered, and the choice of materials discussed. Details are given of several experimental multipliers and the results obtained with them.

THE operation of multiplication in an analogue computer has always been one of the more difficult stages, and there has not so far been available a device which could do this in a simple and reliable fashion. Nearly always complicated circuits are involved, and an accuracy of 1 per cent is seldom achieved. A promising relation to use as the basis for a multiplier is the force acting on a charged particle moving across a magnetic field, this force being proportional to the product of magnetic field strength and the particle velocity. Such a multiplier has in fact been constructed in a special cathode-ray tube[1]. A simpler solution is to use the corresponding effects occurring in a solid viz. the Hall effect, and magneto-resistance.

Hall discovered in 1879 that if a current was passed through a metal at right-angles to a magnetic field a voltage appeared in the mutually perpendicular direction. A simple arrangement for observing the effect is shown in Fig. 1. The Hall voltage is given by

$$V_H = R_H \frac{BI}{t.10^8} \text{ volts}$$

where I is in amperes, B in oersteds and t in centimetres; it may be shown that R_H, the Hall constant, is the reciprocal of the product of the charge on the carriers and their concentration. Since the carrier concentration is much less for semiconductors than for metals, the voltages developed are larger. If the charge carriers have a high

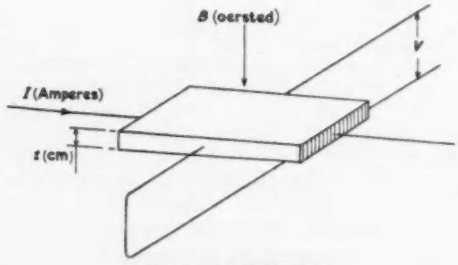

Fig. 1. The Hall effect

mobility a good proportion of the input power to the specimen may be diverted to the Hall terminals.

When the Hall effect is to be used in a multiplier the magnetic field is obtained by feeding one of the input voltages into a magnetizing coil; three questions then arise.

(1) Which semiconductor is the best?

(2) Is the magnetic field proportional to the voltage developing it?

(3) Should the device operate as a voltage or a current multiplier?

The third question provides in some respects an answer to the first. If the multiplier is required to feed into a matched load the choice of materials largely depends on considerations of available power, and this restricts one to the high mobility semiconductors, since the efficiency

* Services Electronics Research Laboratory

of power transfer is proportional to the square of the mobility, and independent of the Hall constant[2]. •If a voltage output into a high resistance is required the mobility is less important, and the numerical value of the Hall constant comes into the relations. It is necessary also to decide whether the multiplier is to use voltage or current input into the semiconductor, remembering that the resistivity is dependent on both the magnetic field and the ambient temperature. The magneto-resistance, the increase of resistance in a magnetic field, is of much smaller magnitude with the lower mobility semiconductors.

Four semiconductors offer themselves for this application, though further development of materials may provide others suitable for the purpose. The four considered may be divided into two classes, silicon and germanium being described as of medium mobility and high Hall constant, and indium antimonide and indium arsenide of high mobility and medium Hall constant. If the temperature stability required is specified then Ge and Si will give the best voltage sensitivity, and InAs the best power transfer.

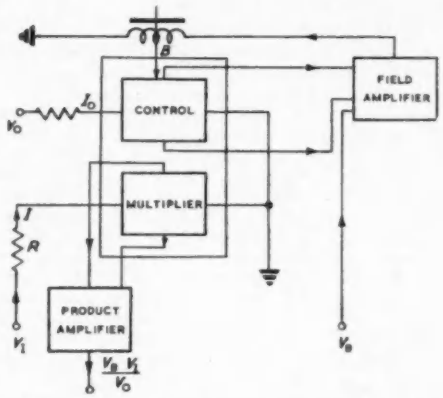

Fig. 2. Block diagram of a multiplier (after Lofgren)

InSb gives the best power transfer of all, but shows pronounced temperature effects.

The second question posed is answered more directly. With a ferromagnetic core with a fairly large air-gap there is a working range over which the field in the gap is proportional to the magnetizing current, but at fields above about 5 000 oersted non-linear effects will be observed. Since the Hall voltage may be made proportional to the magnetic field up to at least 10 000 oersted some workers have thought it worth using special compensation techniques to ensure field proportionality over this range.

The current research on Hall effect multipliers may be illustrated by three examples. The most advanced multiplier has been made by Lofgren[3]. He intended the device to work into a valve amplifier and so chose the regime, current input-voltage output. His initial work was on germanium but recently he has published a description of a silicon multiplier which he considers as superior. It is shown in Fig. 2. One feature worth noting is the method for ensuring magnetic field proportionality. A control specimen is identical to the multiplier specimen. It is driven from a constant current source, and the Hall voltage output applied in opposition to the voltage V_B at the input of a high gain amplifier which provides the magnetizing current. Lofgren shows that the magnetic field produced is almost exactly proportional to V_B.

The regime is made voltage input by putting a large resistance in series with the multiplier specimen, or by driving it from an amplifier designed to give a current output proportional to the voltage input.

Typical operating conditions are:—

Crystal current = 5mA.
Field = 5 000 oersted
Hall voltage = 0·5V
Amplifier inputs = ± 100V maximum
Product amplifier output = ± 20V maximum
Linearity = 0·1 per cent.

The frequency response is limited by the field part of the circuit since the crystal current may be modulated at several megacycles per second. The response time of the field is proportional to the voltage input and with a Ferroxcube core the device responds to maximum input voltage in 1msec. The maximum field is then restricted to 3 000 oersted by saturation in the ferrite. With an iron core the maximum field can be 10 000 oersted but the response is 10 to 20 times slower.

A simpler multiplier using InAs has been developed at the Metropolitan-Vickers Research Laboratory by Chasmar and Cohen and a complete account of their work is given

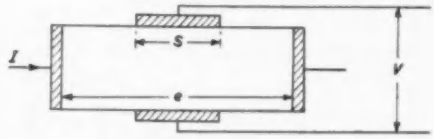

Fig. 3. Hall specimen with widened electrodes

elsewhere in this issue[4]. The unit uses current input and voltage output and the magnetic field is provided via a Ferroxcube core. The maximum field is therefore 3 000 oersted which is obtained with 15mA through the magnetizing coils. No proportionality correction is used but the linearity is better than 1 per cent. Typical operating conditions are

Crystal current = 200mA
Field = 2 500 oersted
Hall voltage = 0·12V.

The indium arsenide specimen has a resistance of 5·6Ω and the coil a resistance of 500Ω and an inductance of 5H. The resistance between the Hall probes is 4·1Ω.

Another indium arsenide multiplier has been described by Kuhrt[5], of the Siemens Laboratories. He was interested in obtaining power transfer and gives considerable detail of the techniques necessary for obtaining linearity in current input-current output regime. It was found that the magneto-resistive effects were large enough to cause errors when feeding into a matched load, the specimen resistance increasing with the magnetic field. A square shaped specimen of InAs more than doubles its resistance in a field of 10 000 oersted and this displays itself as a departure from linearity in the multiplier output at the higher fields. The effect can be compensated by using Hall electrodes of a finite width as shown in Fig. 3. The experimental results are illustrated in Fig. 4, where it is apparent that by using electrodes of one tenth the specimen length and working into a load resistance three times the zero-field specimen resistance a linearity error of <1 per cent can be obtained. An alternative method is shown in Fig. 5. An InAs control specimen is placed in the field air-gap and connected in parallel with the Hall specimen. The control is shaped to have a greater magneto-resistive effect than the Hall unit, and as a result a greater propor-

tion of the driving current passes into the Hall unit at the higher fields. The resistances shown are adjusted so that this extra current is of correct magnitude to counterbalance the non-linearity.

The magneto-resistive effects have been mentioned earlier as 'nuisance' effects, tending to make the Hall effect multipliers inaccurate. Simpson[6] has shown that an accurate multiplier may be made by use of these same effects. His device is shown in Fig. 6. Two identical specimens of indium antimonide or indium arsenide are arranged in air-gaps in a magnetic core so that a biasing field B and a mutiplier field W can be applied to them. For one specimen the multiplier field supplements the bias, and for the other it is subtracted from it. The change of resistance ΔR is proportional to the square of the magnetic field. The two specimens are connected in a Wheatstone bridge in one of two arrangements (Fig. 7(a) and (b)). The resistances of the other two arms and of the load are chosen to give the most linear operation. The first arrangement gives excellent linearity for voltage or current output but the input impedance is slightly dependent on the magnetic field. The alternative system is not quite as linear, but the input impedance is more constant. Little experimental work has been done on this device but it provides an interesting alternative to the Hall effect multipliers.

In this short account no mention has been made of the difficulties involved in the construction of the multiplier units. The contacts must be made non-rectifying, and for Hall specimens there must be no residual output voltage in zero magnetic field. For devices using two elements there are the obvious problems of matching. All of these points are being investigated and there is little doubt that the problems will be solved. The designer of analogue computers will then have available a multiplier which will ease his task considerably.

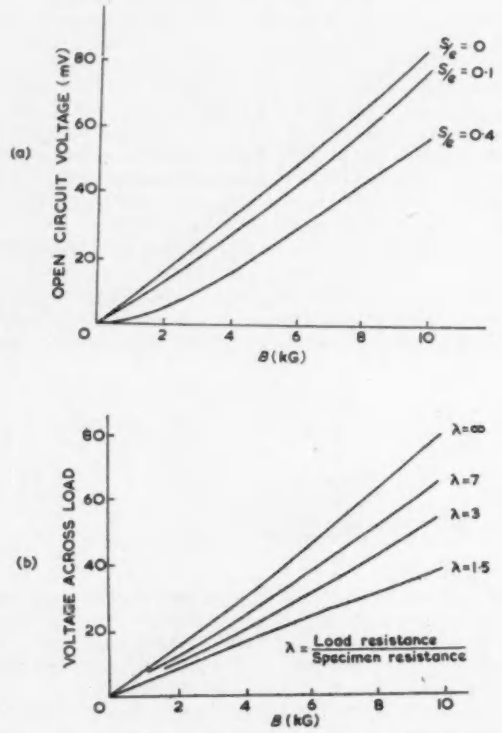

Fig. 4. Obtaining linearity by use of wide Hall electrodes (after Kuhrt)
(a) Open-circuit characteristics
(b) Effect of varying load resistance on linearity S/e = 0·1

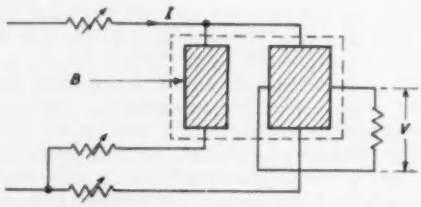

Fig. 5. Correcting for non-linearity with a magnetoresistive control (after Kuhrt)

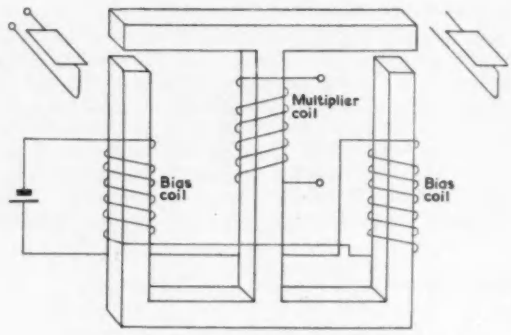

Fig. 6. The magneto-resistive multiplier

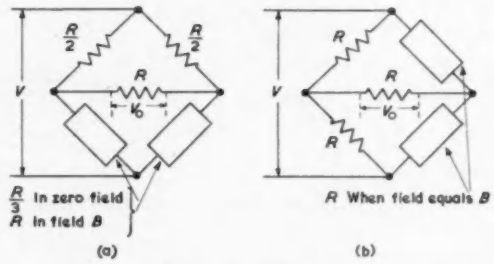

Fig. 7. Connexion of magneto-resistive multiplier
(a) For B = 3kG, an input field C causes an output

$$V_o = \frac{V(C/B)}{2/1+C^4/4B^4}$$

An input of 1kG gives a non-linearity of 0·3 per cent and one of 500G, a non-linearity of 002 per cent. (b) A voltage V applied to the multiplier coil gives a field C, less than the field B

$$V_o = \frac{V(C/B)}{3+7/6\ C^2/B^2}$$

B = 3kG, C = ±500G for 1 per cent non-linearity

Acknowledgment

The author is grateful to the Admiralty for permission to publish this article.

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Short News Items

The College of Aeronautics, Cranfield, held an Open Day recently. The aircraft industry, Ministries and Services, airlines, universities, colleges, press and others were represented. The formation of the College was first officially proposed by Sir Stafford Cripps, then Minister of Aircraft Production. The College was established in January 1946 in the former Royal Air Force station at Cranfield. The purpose of the College is to provide engineering and scientific training in aeronautics at post-graduate level, to enable students to develop a capacity to fill in due time senior and responsible positions in the aircraft industry, civil aviation, the Services, education and research.

The Board of Directors of Electric & Musical Industries Ltd has decided to close the E.M.I. College of Electronics with effect from July 1959. Over the past few years E.M.I. Electronics Ltd has found an increasing necessity to meet the training requirements of its technical staff, and steps have been taken to increase the training facilities within its own organization at Hayes and its various branches. It is also taking greater advantage of the increasing variety of courses now being offered by universities and technical colleges. Intending students on one-year courses in the Principles and Practice of Radio and Television may, however, still apply for enrolment with the E.M.I. College for courses commencing on 6 January and 14 April 1959. The E.M.I. College will be responsible for the instruction of students until 29 July 1959. After that date, they may, if they so wish, complete their courses at the Pembridge College of Electronics, 34a Hereford Road, London, W.2, which Mr. J. B. McMillan, M.A., B.Sc., the present Director of Studies of the E.M.I. College of Electronics, is founding and in which he will be assisted by members of his present staff. The Pembridge College which will open in September 1959, after Mr. McMillan and his staff have relinquished their present positions with the E.M.I. College will conduct, as one of its activities, courses based on the one-year course syllabus at present used by the E.M.I. College of Electronics.

The BBC has placed an order with E.M.I. Electronics Ltd for six f.m. transmitters of a new type for the v.h.f. sound station now being built at Llanddona, North Wales. The station, which will provide a full service of Home, Light and Third programmes, will serve some 180 000 people living in Anglesey and North Wales. The BBC has also ordered six similar transmitters for the new station to be built at NetherButton, Orkney. The new method of f.m. used provides an improved signal-to-noise ratio with reduced harmonic distortion.

The Institution of Telecommunication Engineers (India) is to hold a Second Technical Convention on 27-28 December. Further particulars may be obtained from the Honorary Secretary, The Institution of Telecommunication Engineers, Post Box No. 481, New Delhi.

The Council of the Institution of Electrical Engineers, with the encouragement of members of the medical profession, have instituted a Medical Electronics Discussion Group, to provide a forum in which electrical engineers specializing in electronics can meet members of the medical profession to discuss problems in which they have a common interest. The Group will hold regular meetings having the nature of colloquia at which subjects coming within the field of medical electronics will be discussed. The affairs of the Group will be guided by a committee broadly representative of members of both professions who are prominent in this field. The Council have noted with interest the outcome of the International Conference on Medical Electronics which, on the initiative of Dr. V. K. Zworykin, was held in Paris in June of this year, and feel that the second International Conference which it is planned to hold in 1959, is worthy of support. They have therefore agreed that the Group Committee should receive on behalf of Dr. C. N. Smyth, a Vice-President of the Interim Committee of the International Conference and Chairman of its Papers Committee, notice of any papers coming from British sources. Any person interested in the activities of the Group should send his name and address to the Secretary of the Institution of Electrical Engineers, Savoy Place, London, W.C.2, for inclusion in a mailing list for details of the Group's activities, which is now being compiled.

A Short General Purpose Analogue Computer is to be installed in the Department of Electrical Engineering at McGill University, Montreal. It will be used for research on electrical circuit design and control system analysis. The instrument is being shipped to Canada as a joint venture by Short Brothers and Harland Ltd and The Bristol Aeroplane Co of Canada Ltd. It is hoped that as well as being used for research at McGill, it will be available for use by outside organizations and for demonstration to some of the smaller industrial groups in the provinces of Quebec and Ontario. The computer will be equipped with the latest continuously drift-sorrected units, designed for high-speed repetitive computation. Though basically similar to Short computers already in service in the U.K. and overseas, it has been specially adapted for operation on the higher frequency supply system used in North America.

The European Division of Electronic Associates, Inc, at 43 rue de la Science, Brussels, has announced the sale of a large general purpose Type 231R PACE analogue computer to the United Kingdom Atomic Energy Research Centre at Harwell. This system contains high accuracy linear and non-linear computing components, modular patch panel and ADIOS system which allows the computer to be programmed by paper tape or electric typewriter. The company maintains sales, service and training facilities at Brussels and, in addition, provides rental service and consulting engineering advice on a PACE computer installed there.

The BEAMA Publicity Conference 1958 will be held on 11 and 12 November. Attendance is open to BEAMA member firms only.

The Institution of Electrical Engineers mention that the Faraday Lecture 1958/59 will be presented by Dr. H. A. Thomas at the Royal Festival Hall on Monday, 26 January, 1959, at 6 p.m., on the subject of "Automation". Dr. Thomas is Manager of the Instrumentation and Control Section of Unilever's Engineering Department. Admission will be free by ticket available from the Institution, Savoy Place, London, W.C.2. Applicants are requested to enclose a stamped addressed envelope.

Hayward & Martin Ltd of Bromley, Kent, offer a complete service for engineering and electronic concerns, covering the preparation of instruction material, with particular reference to handbooks, sectioned and perspective illustrations, in line, half-tone and full colour. They also deal with the production of sales promotional material and technical publications from the commercial standpoint. They are officially accredited contractors to H.M. Government, including the U.K. Atomic Energy Authority and the Ministry of Supply. Further details may be obtained from 34, High Street, Bromley, Kent.

Lewis Berger (Great Britain) Ltd mention that they frequently receive inquiries regarding the supply and use of strain sensitive lacquers which probably arise from the fact that they were cited as suppliers some years ago in the monograph *Resistance Strain Gauges* by J. Yarnell, published by us. (Morgan Bros (Publishers) Ltd). The position is that, while they may, some while ago, have supplied an experimental sample for such use, they do not regularly manufacture, and have no technical background of experience in the use of these materials which would enable them to advise.

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Error-Integration in Servomechanisms

DEAR SIR,—The benefits of error-integration in servomechanisms are well known. However, its use can lead to trouble in handling large disturbances when torque-saturation occurs. I have recently been working on a servo including error integration, which went

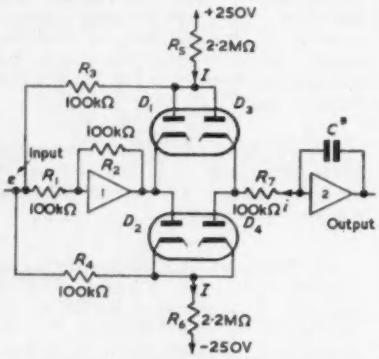

Fig. 1. Circuit diagram (*replaced by 100kΩ resistor for obtaining Fig. 2)

viciously unstable after application of a large step demand. To overcome this the integrator was disabled for error signals exceeding a fairly small value. This idea is not new, but the circuit employed (Fig. 1) may be of interest, and has the advantage that very good clamping of the integrator may be obtained without the necessity for carefully matched components. The experimental characteristic shown in Fig. 2 was obtained using a 100kΩ resistor instead of C.

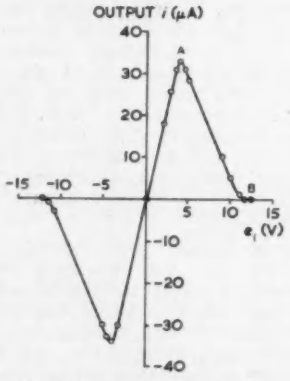

Fig. 2. Input-output characteristic

The d.c. amplifiers used in the experimental circuit had a voltage gain of about 500 times, and cathode-follower outputs, although these could doubtless be simplified if required.

Explanation may be simplified by assuming the resistors R_5, R_6 with the h.t. lines to be sources of constant current I. For small signals the current I divides between all the diodes, which therefore couple the inverting amplifier 1 to the integrator. The shunting effect of R_3 and R_4 is minimized by the low output impedance of amplifier 1.

As the input signal e increases in the positive direction, the currents in D_2 and D_3 diminish, becoming zero at the point marked A on the characteristic of Fig. 2. The current i in R_7 has meanwhile been increasing in the sense indicated.

A further increase in e decreases i (the invertor amplifier being now disconnected from R_7), and eventually when i reaches the value I, D_4 ceases to conduct. For any further increase in C, R_7 is effectively disconnected at the diode end. It may be noted that the integrator is thus effectively clamped even if there is a zero error in amplifier 2. A further test with a 1μF capacitor for C indicated a current in it of about 10^{-9}A (more or less independent of the zero settings) for inputs outside ±12V.

To date two specimens of this circuit have been constructed with no attempt to select or match components, and have given the above performance without any difficulty.

Yours faithfully,

R. S. TAUNTON

The Staveley Research Department,
Bedford.

Some Methods of Phase Measurement used in Transfer Function Analysis

DEAR SIR,—The article by D. J. Collins and J. E. Smith, which appeared in your April 1958 issue and in which the authors surveyed among others some of the techniques of phase-difference angle estimation using a single-beam cathode-ray oscilloscope, particularly interested me.

Since measurements of this sort are limited in accuracy by such considerations as deflexion linearity, spot size, and harmonics, the appeal of such methods must lie in the ease with which they can be employed. In this light, I suggest that two additions to the authors' section (1(b)) are needed.

First, in the right-hand drawing of Fig. 2 of Collins and Smith, not only is

$$\text{Phase shift } \phi = 2 \tan^{-1} B/A$$

but the angle between rays joining the ends of the minor diameter and one end of the major diameter is indeed the phase shift angle ϕ, which may be measured directly with a protractor.

Second, since most oscilloscopes are equipped with a graticule, a method I have described[1,2] is most attractive. Briefly, if the Lissajous ellipse is inscribed in a square 24 divisions on a side, direct approximation, within one degree due to method, of angles between zero and 70° is possible. Further, a correction which may be applied by mental computation extends the usefulness of the method to include all angles, the error due to method lying between zero and plus one degree or within plus or minus a half degree.

Very truly yours,

CARL R. WISCHMEYER

The Rice Institute,
Houston, Texas.

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The Authors' reply:

DEAR SIR,—We are indebted to Mr. Wischmeyer for his constructive note. He appears to have evolved a measurement system which is relatively simple but requires an oscilloscope with special features.

In general, the oscilloscope should have exceptionally good deflexion linearity, small spot size and have identical X and Y systems with continuously variable gain controls.

However, even with this special oscilloscope it is very debatable as to whether a 1 degree accuracy can be achieved. If, for example, we have a 5in cathode-ray tube with a value for R of 2in, the scale factor is 0·022in per degree, which necessitates careful measurements.

The use of the oscilloscope for phase measurement is best suited to the higher frequencies where other techniques fail and we would emphasize that large errors can occur if the measured voltages have harmonic content[1].

Yours faithfully,

D. J. COLLINS
J. E. SMITH

Solartron Research & Development Ltd.

REFERENCE

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Gating of Threshold Signals

DEAR SIR,—The output when taken either from the cathode or the anode of a conventional gating circuit, is superimposed on a pedestal, due to the gating

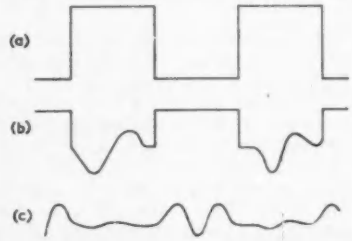

Fig. 1. Comparison between the output waveforms of the threshold and conventional gates (a) Gating waveform, (b) Cathode output from conventional gate, (c) Cathode output from circuit of Fig. 2

waveform as shown in Fig. 1. When the signal to be gated is very small, this pedestal may be intolerable.

A simple re-arrangement of the circuit enables a gated output to be obtained, substantially free from the pedestal, and is of considerable use in applications involving threshold signals.

In the circuit described below gating is obtained by gain discrimination between the open and closed condition. In a typical circuit, discrimination of 10 to 20 to 1 can be obtained and this is usually sufficient for most applications.

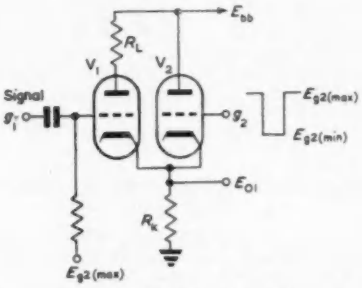

Fig. 2. Threshold signal gate

The circuit and voltage levels are shown in Fig. 2 and in Fig. 1 its output waveform is compared with that of a conventional gate.

In the conventional double triode gate the signal grid bias is arranged to lie somewhere between the variations in grid potential of the switching waveform. Thus, when the gate is open V_1 is conducting and V_2 is cut off and when the gate is closed the opposite occurs.

However, from Fig. 2 it will be observed that the bias on the signal grid is made equal to the maximum switching potential on the second grid. The output is taken from the cathode.

When the switching potential is high both valves are conducting and the cathode potential is slightly higher than either grid potential. The circuit operates

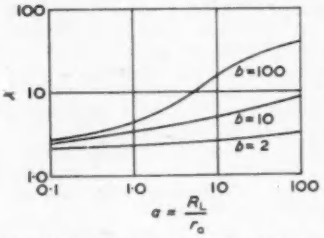

Fig. 3. Variation of gain discrimination ratio as a function of a and b

as a conventional difference amplifier, a very small signal appearing from cathode to ground.

On the other hand, when the switching potential is low, the cathode potential remains just above the potential of grid 1. There is a considerable increase in the anode current of the first valve but little change in the current in the cathode resistor. The second valve is cut off and the first acts like a cathode-follower.

Let E_{01} = the output voltage when the gating voltage is high (gate closed)

and E_{02} = the output voltage when the gating voltage is low (gate open)

The voltage discrimination ratio

$$X = (E_{02}/E_{01})$$

and is given approximately

$$\text{by } X = 1 + \frac{b(1 + a)}{1 + a + b}$$

where $a = (R_L/r_a)$ and $b = g_m R_K$

The above relationship is graphed in Fig. 3 and it can be seen that for R_L less than $10r_a$ there is little point in making R_K exceed $10/g_m$.

Practical values of X are about 10 times and in order to exceed this it is necessary to have very high values of R_L and R_K.

Similarly, an output impedance discrimination ratio may be defined as $Y = (Z_{02}/Z_{01})$ and for this gate

$$Y = \frac{1}{1 + \dfrac{b(1 + a)}{1 + a + b}}$$

When the outputs of n gates are to be paralleled it can be proved that $XY/(n - 1)$ should be $\gg 1$.

Unfortunately as $XY = 1$ for this threshold gate, before such gates can be joined in parallel a buffer valve output is necessary for each one.

Yours faithfully,

G. W. TAYLOR
South Woodford,
London, E.18.

On Measuring the Admittances of a Four-Terminal Network

DEAR SIR,—It is often desirable to consider an electrical or electronic device as a four-terminal network, and to measure some set of four-terminal properties. A convenient set is the admittance parameters, which are matrix elements given by

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \qquad (1)$$

Here i_1 and i_2 are the currents into the four-terminal at each end, V_1 and V_2 the voltages applied at each end, and the y's the admittances.

One way of measuring all these values is to measure the input admittance at each end of the network, the other end being first open-circuit and then short-circuit. If the network is known to be reciprocal, so that $y_{21} = y_{12}$, one of these four measurements is redundant; while if the network is reciprocal and symmetrical, two non-equivalent measurements will suffice.

Active devices, such as thermionic valves and transistors, will, in general, be neither reciprocal nor symmetrical. Thus all four measurements would be required. However, there may be difficulty in achieving some of the open- and short-circuit terminations. It is difficult, for example, to get an open-circuit (impedance much larger than the internal impedance) for the grid of a thermionic valve; the collector of a transistor may present the same problem.

Some of these difficulties may be overcome by a measurement which seems to have been little noticed, namely that of the admittance, as a two-terminal, of the four terminal with input and output connected in parallel. It is apparent that the admittance measured would be just the sum of the four admittances from the matrix in equation (1). Then three other measurements would determine matters completely; and, in some cases, it might be possible to dispense with some of them.

A valve at moderate frequencies, has $y_{21} = g_m$ and $y_{22} = 1/r_a$, g_m being the transconductance and r_a the anode resistance. The other y's are much less than these; and, moreover, they will be predominantly imaginary, while g_m and $1/r_a$ are real. Accordingly, a measurement of input admittance to the anode with the grid shorted to the cathode, and to the anode and grid tied together, will determine these quantities.

For a transistor in the common-emitter configuration, all four y's will often be wanted. A measurement of the input admittance to the base with the collector shorted, to the collector with the base first open and then shorted, and to the base and collector tied together, will give the desired information. The input admittance to the base is ordinarily of such a magnitude that it is not difficult to achieve either an open- or short-circuit termination, whereas it might be difficult or impossible to achieve a true open-circuit termination at the collector.

The valve and transistor are really three terminal networks. For a true four-terminal network there is another possible measurement, in which the input and output are connected in parallel, but one is reversed. This measurement would give $y_{11} - y_{12} - y_{21} + y_{22}$. It might be possible, in some cases, to get the same result with a three-terminal network by using transformers.

It should not be overlooked, of course, that this process might be reversed, measurements of transfer admittances and impedances being used to deduce input and output admittances or impedances. This might be worthwhile, since equipment for measuring transfer admittances and impedances is available.

In conclusion, it is believed that the measurement of the input admittance to the two ends of a four-terminal network connected together can be a handy method of avoiding a more difficult measurement. This technique has surely been noticed before, but the writer does not recall ever seeing any mention of it, and a reminder may thus be helpful.

This discussion was prepared while the writer was with Pacific Semiconductors, Inc., Culver City, California, U.S.A.

Yours faithfully,

H. L. ARMSTRONG
Department of Physics,
Queen's University,
Kingston, Ontario.

BOOK REVIEWS

Switching Circuits and Logical Design

By S. H. Caldwell. 686 pp. 300 figs. Demy 8vo. John Wiley & Sons Inc., New York. Chapman & Hall Ltd, London. 1958. Price 112s.

THIS book is a major contribution to the rather limited range of basic text-books on this subject, and some useful methods of analysis and synthesis presented in it have only previously been published in rather inaccessible papers.

The presentation of the subject is very clear, and tables and diagrams are carefully explained. The engineer dealing with many day to day problems may feel that the methods developed in the earlier chapters are rather like taking a sledge-hammer to crack a nut, but it should be pointed out that the book is based on lectures given to students at M.I.T.

There are two introductory chapters, the first indicating the applications and objectives of switching circuits, and the second describing some of the commonly used switching components. Switching algebra is then introduced and references made to the work of Shannon and to the algebra of logic developed by Boole. After dealing with the postulates and basic theorems as an abstract structure, they are repeated using relay contacts to give a physical significance to the algebra. After a chapter which extends the theory and includes analysis and synthesis of contact networks, we come to the problem of minimization. This is a difficult problem if a reasonable number of variables is involved, and one of the methods described seems to represent a considerable advance. It is a modification by McCluskey of the Quine method, and results in a considerable saving of labour and simplification in handling the comparison stages of the process. The various methods yield an expression in the form of a minimum sum (or product). This may or may not be a unique minimum and in any case does not necessarily represent an optimum engineering solution. The designer must still rely on art and experience at this stage and a completely analytical solution seems unlikely, particularly as an optimum design is often difficult to define. There are five further chapters on combinational networks, one of them extending the theory to cover most of the high speed switching elements. Rectifiers, valves, transistors and magnetic cores are discussed and some of the engineering limitations pointed out.

The remainder of the book deals with sequential circuits and here again the basic methods seem to be an advance on those employed by many engineers. Electronic and solid-state devices are again discussed both in sequential and pulsed sequential circuits.

The use of the terms 'add gate' and 'multiply gate' in place of 'or gate' and 'and gate' is of little consequence; but the introduction of special symbols for gates using grids one and three of a pentode, and double triodes with commoned anodes, is in the reviewer's opinion confusing and quite unjustified in a logical diagram.

The student with no previous knowledge of the subject will have no great difficulty with this book and a useful range of problems is included at the end of each chapter; it is however a very long book and a thorough study of it is a major undertaking. It will certainly lead most engineers to think more clearly about the design methods they employ, but in many cases (certainly in high speed switching) the detailed formulation of the problem often goes hand in hand with trial solutions, and text-books can never replace clear thinking and experience for this type of design work.

F. BECKETT

Progress in Semi-conductors—Volume 3

Edited by A. F. Gibson, P. Aigrain and R. E. Burgess. 210 pp. 44 figs. Demy 8vo. Heywood & Co. Ltd. 1958. Price 55s.

AS in the two previous volumes in this series a wide variety of topics is presented as may be seen from the chapter headings: The Magnetoresistivity of Germanium and Silicon; the Chemical Purification of Germanium and Silicon; Electronic Conductivity of Silver Halide Crystals; Silicon Junction Diodes; Lifetime of Excess Carriers in Semiconductors; Scattering and Drift Mobility of Carriers in Germanium and finally Electronic Processes in Cadmium Sulphide. In calling on specialist authors for contributions, the editors have weighted the book in favour of germanium and silicon in view of their prime technological importance, but at the same time have included material on compound semiconductors.

The chapters on magnetoresistivity and bulk scattering processes are critical review articles which are admirable surveys of existing knowledge: they show that there is still much work to be done before a full understanding of the fundamental physics of the elemental semiconductors is achieved. That on lifetime is largely concerned with carrier recombination via intermediate centres which arise either from bulk imperfections or surface states in wide-gap semiconductors; the case of band-to-band transitions which is relevant for narrow-gap semiconductors is, however, also considered. The one paper dealing with devices—silicon junction diodes—deals adequately with their preparation; on the theoretical side, however, it is somewhat limited because of the lack of detailed agreement shown between experimental characteristics and those based on theory.

While the present standard is maintained it is clear that the usefulness of this series of annual volumes to the pure research worker, device designer and teacher is very great. Although not all the topics will be of direct interest to any one reader the specialist cannot afford to be unaware of the reviews presented here, which cover fields adjacent to his own. For those who are mainly interested in the performance of devices considerable benefit is to be gained from a study of those reviews dealing with the fundamental electronic processes.

F. J. HYDE

Transient Response from Frequency Response

By V. V. Solodovnikov, Yu. I. Topcheev, and G. V. Krutikova. 193 pp. 69 figs. Super Royal 8vo. Infosearch Ltd. distributed by Cleaver-Hulme Press Ltd., London. 1958. Price 42s.

WITH scientific and official co-operation from the U.S.S.R., Infosearch Ltd. of London has recently undertaken the production of a series of English translations of books by leading Russian scientists in the fields of physics, electronics, chemistry, metallurgy, and engineering. Some of these are now ready and are being distributed by Cleaver-Hulme Press Ltd. Among the first to appear is *Transient Response from Frequency Response* which has been translated and edited by A. Gelbtuch; the original was published in Moscow in 1955. Professor Solodovnikov, the first of the three authors, is at present in charge of the Central Research Institute for Complex Automation of the U.S.S.R. Academy of Sciences.

The book presents a development of G. F. Floyd's procedure for determining the transient response of a linear automatic control system from its frequency response. The system may be of minimum or non-minimum phase type with discrete or distributed parameters and may have a time delay. The frequency response of the system is first determined analytically or experimentally. By a graphical process, a set of trapezoids is then derived from the frequency response curve and a graphical representation of the transient response is obtained with the aid of tables of the function

$$h\kappa(t) = 2/\pi \left\{ S_i(\kappa t) + \frac{1}{1-\kappa} \left[S_i(t) - S_i(\kappa t) + \frac{\cos t - \cos \kappa t}{t} \right] \right\}$$

The primary purpose of the book is to provide fuller tables of this function than have previously been available. The tables are given for a hundred different values of κ from 0 to 1·00 at increments of 0·01 and the values of t range from 0 to 50·0sec at increments of 0·2sec.

The book contains three chapters. The first introduces the theory of the method

and the second provides a wide selection of examples illustrating how the method is applied. The third chapter contains over a hundred pages of tables and nomographs to facilitate computation; the nomographs are printed on separate sheets and stored in a pocket at the back of the book.

S. R. DEARDS

Dilogarithms and Associated Functions

By L. Lewin. 353 pp. Demy 8vo. Macdonald and Co. (Publishers) Ltd. 1958. Price 65s.

THE title of this book is certain to fascinate anyone who sets eyes on it and he will not be disappointed. The author was stimulated by mathematical curiosity to investigate these functions so that, although later on writing up his results he found that many had been obtained before, his book has all the zest and enthusiasm of the pioneer.

Thus we can add a new name to the list of 'recognized' functions such as those of Legendre and Bessel. If any reader of this review is wondering—just as the reviewer did—what a dilogarithm is, he ought to read this book, for surely it is not for the reviewer to tell him.

Most of us have probably come across the function known as a dilogarithm in the course of our calculations but, until the reviewer read this book, he was quite unaware in how many different places it has occurred, including electrical network theory. In fact, the field of applications has been so wide that perhaps only Dr. Lewin, whose interests led him to explore them all, could have appreciated that the time was ripe for a book.

The dilogarithm, the trilogarithm and indeed the logarithm are all special cases of a class of functions studied by many mathematicians and the first monograph on them was written as long ago as 1809 by Spencer. Until this book appeared there has not been another, but Dr. Lewin has studied the literature exhaustively and not only collected and ordered the properties of the functions and many curious related facts, but included many new results and connexions of his own. The result is a valuable monograph including numerical tables of the main functions, which is not only extremely useful but will certainly stimulate those who read it.

G. J. KYNCH

Basics of Digital Computers

By John S. Murphy. 196 pp. (3 vols.). 80 figs. Demy 8vo. John F. Rider Publisher, Inc., New York. Price $6.95.

VOLUME 1 of this three-volume course reviews the development of computers and then explains the basic theory of computer arithmetic, data representation, circuits and control. Volume 2 discusses the logical elements and volume 3 deals with the system aspects of computers with discussions of types of memory, control systems, and input-output equipment.

Radio Valve Data

Compiled by 'Wireless World.' 136 pp. Medium 4to. 6th Edition. Iliffe & Sons Ltd. 1958. Price 5s.

THE latest edition of this widely used reference book has been enlarged and made easier to use. It now contains operating data on over 3 000 British and American radio valves, transistors, rectifiers and cathode-ray tubes. Twenty British manufacturers are represented, all of whom have co-operated with Wireless World to ensure that the information given is accurate, comprehensive, and up to date. A new feature of this edition is that the valve base connexion codes have been included in the index, as well as being retained in the main tables.

Elementary Engineering Science

By A. Morley and E. Hughes. 381 pp. 182 figs. Demy 8vo. 4th Edition. Longmans, Green & Co. Ltd., New York, Toronto, London. 1958. Price 11s. 9d.

THIS volume covers the Mechanics, Heat and Electricity sections of the syllabus in Science (Building and Engineering), Ordinary Level, of the Associated Examining Board for the General Certificate of Education and may therefore be found suitable for use in preparing pupils for this examination. It also covers the first year syllabus in Electrical Engineering Principles of the City and Guilds of London Institute's Courses for Electrical Technicians. The symbols and nomenclature are in accordance with the recommendations of the British Standards Institution. Twenty years have elapsed since the first edition of this book was published.

Chamber's Technical Dictionary

1028 pp. Demy 8vo. 3rd revised edition. W. & R. Chambers Ltd. 1958. Price 35s.

THIS new edition contains 55 000 entries drawn from more than 100 branches of scientific and industrial activity. It includes a 74 page supplement with nearly 5 000 definitions of important new terms covering the latest advances in science and technology.

Among the additions are aeronautical terms dealing with supersonic flight, guided missiles, aero engines; new chemical substances; definitions of electronic terms used in connexion with computers, automation, and colour television.

The Principles of Technical Electricity

By M. Nelkon. 250 pp. Demy 8vo. 3rd Edition. Blackie & Son Ltd. 1958. Price 15s.

THIS exposition of the fundamentals of electricity deals with the subject to the standard of the City and Guilds Telecommunications examination, Principles I and II. The usual introductory topics are covered and lead up to a.c. circuit theory, valves, typical radio circuits, and the cathode-ray oscillograph. For this third edition the text has been rewritten using the m.k.s. system of units which is now widely adopted. A comparison with c.g.s. units is given in the appendix.

EE 3236 *for further details*

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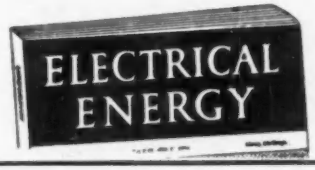

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EE 3237 *for further details*

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

TACAN PERFORMANCE TESTER

(Illustrated below)

G. & E. Bradley Ltd., Electrical House, Neasden Lane, London, N.W.10.

THE Tacan performance tester is a portable 'go no-go test set' designed to check the efficiency of the airborne equipment used with both the British and American Tacan air navigation systems. The test set operates on channel 39, and is capable of checking the complete aircraft transmitter-receiver installation. It also provides an indication of the power output on all 126 channels.

Measurements of receiver sensitivity or transmitter power on channel 39 are referred back to the transmitter-receiver and presented as an 'accept/reject' indication of its performance. This is achieved by simulating the complex video, audio and r.f. waveforms generated by the beacons normally used

with the Tacan system. Receiver sensitivity at a frequency of 1 000Mc/s is checked by the test set at a simulated range of 5 or 105 miles, and at bearings of 140° or 320°. Both range and bearing facilities are selected by switches on the front panel. The point at which the aircraft indicators 'lock on' to the signals generated by the test set is interpreted as a pass or reject mark, dependent upon the sensitivity of the receiver. Normal beacon identity tone at 1 350c/s is maintained at the pilot's headset during all receiver measurements.

The test set will also provide an accurate measurement of the aircraft transmitter power at a frequency of 1 063Mc/s, again using the same accept/reject principle, and based on a minimum peak pulse power of 1kW. An assessment of the power generated on any of the 126 channels may also be made, but without the pass mark facility. Connexion between the test set and the Tacan equipment is made via an 18ft length of coaxial cable and a calibrated fixed attenuator, which is used for tests carried out either at the aircraft or in the workshop.

Portability and simplicity of operation are features of the test set which may be operated wherever a suitable power supply is available. It will operate from a normal 400c/s 115V aircraft power supply, or at 180 and 200V, 320 to 1 760c/s. Its power consumption at 400c/s is 100W.

The equipment is contained in a carrying case which is designed to withstand complete immersion in water, and proofed against the corrosive effect of salt water.

The test set is designed and built to meet the requirements of the Services, and has full type approval.

EE 3751 *for further details*

SPECTRUM ANALYSER

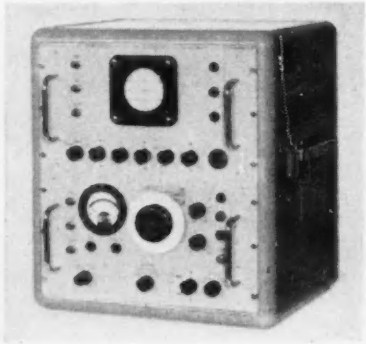
(Illustrated below)

James Scott & Co. (Electrical Engineers) Ltd., 68 Brockville Street, Carntyne Industrial Estate, Glasgow, E.2.

THIS instrument can be used at audio and supersonic frequencies to analyse the spectrum of a complex or simple signal. The frequency range of the standard instrument is from 1kc/s to 90kc/s, but custom-built equipment for other frequency ranges is manufactured to order.

The analyser provides two alternative presentations of the spectrum. For rapid qualitative analysis, the spectrum is displayed on a cathode-ray oscilloscope. The 'x' co-ordinate of the trace represents the frequency scale and the 'y' co-ordinate the power level at any frequency. Accurate calibration of the frequency scale is made possible by imposing a marker 'blip' on the trace derived from a calibrated manually controlled oscillator.

In order to make an accurate analysis of the power distribution at any part of the spectrum, the marker blip is lined up on the point of interest and the analyser switched to 'manual' operation. The manual oscillator setting now determines the centre frequency at which the measurment is made by means of a thermocouple milliameter. The signal power level is determined by using an accurate, calibrating oscillator, the meter indication always being set to a constant value by attenuator adjustment.

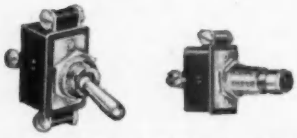


The automatically swept oscillator can be switched to scan either 1 to 7kc/s or 1 to 100kc/s across the tube at a rate which may be controlled by the user.

The power in a part of the spectrum can only be expressed with reference to the bandwidth in which this is measured, in this equipment 1kc/s or 70c/s. The response of the narrow-band filter represents a close approach to the ideal 'plateau' as it incorporates no less than six staggered crystal filter elements.

In addition to its function as a spectrum analyser at frequencies up to 90kc/s, the instrument can also be employed for work at higher frequencies by the use of a suitable superheterodyne receiver in which the i.f. must naturally have a minimum bandwidth of 100kc/s.

EE 3752 *for further details*



HEAVY DUTY TOGGLE SWITCHES

(Illustrated above)

Radiospares Ltd., 4-8 Maple Street, London, W.1.

INCLUDED in the large number of components listed in their new catalogue Radiospares Ltd. have a new range of heavy duty toggle switches.

These switches are rated at 250V, 3A a.c.; they are for single hole, 7/16in diameter, fixing and are fitted with screw terminals. They are available in s.p.s.t., d.p.s.t., and d.p.d.t. types.

A push toggle version is also available. This has a d.p.s.t., push-to-make, push-to-break action and is also rated at 250V, 3A a.c.

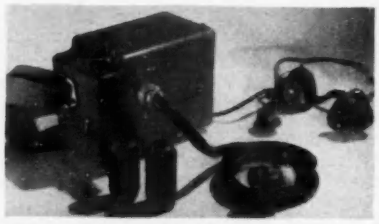
EE 3753 *for further details*

PORTABLE CABLE TESTER

(Illustrated above right)

De Havilland Propellers Ltd., Hatfield, Hertfordshire.

THE de Havilland cable test set provides, in easily portable form, the facilities for checking the continuity and insulation of multi-core cable looms hitherto available only in fixed or cumbersome equipment, Although initially designed for checking electrical systems in aircraft, the unit is of particular value in any type of installation where cabling is already in place, or where the cable runs are in confined spaces: its applications thus extend to many types of industry, including shipping, railways, mining, communications systems and factory maintenance.



Either a continuity or an insulation check can be carried out from one end of a cable run, the far end being terminated by a small unit weighing less than ¼lb (450g). A test is initiated by a press button and the instrument automatically selects each wire in turn. The identification of the core undergoing test is indicated in a window which is illuminated by a red light if failure occurs, in which case the selector stops at the faulty core. Successful completion of a test sequence is indicated by the extinguishing of a separate indicator lamp. A reset button prepares the test set for a further test sequence.

A single outlet from the test set can be adapted for use with any cable by means of a suitable coupler supplied against the customer's requirements. In the case of a connector having a multi-position keyway (e.g. Plessey Mk IV) the coding is checked by a clearly marked movable keyway on both the coupler and termination units.

To enable long cable runs to be tested in conditions where the termination unit is more conveniently attached by a second operator, an intercommunication amplifier is incorporated in the instrument, connexion being made via the cable under test. Standard service style headsets may be used.

When this system is in use the operators receive an additional audible signal as each test is made and can distinguish when a cable failure is detected.

The speed of operation is 5 conductors/sec on continuity and up to 1 conductor/6sec on insulation, the test voltage being 500V d.c. The connector capacity is up to 25 ways per test.

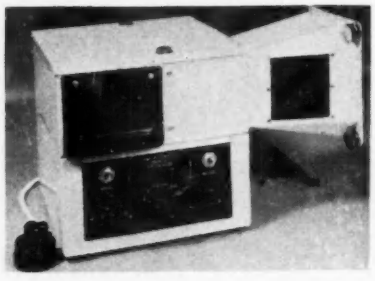
EE 3754 *for further details*

OSCILLOSCOPE CAMERA

(Illustrated below)

Cardiac Recorders Ltd., 63 Weymouth Street, London, W.1.

THE type 23A oscilloscope camera has been designed to bridge the gap between galvanometer multi-channel recorders and normal 35mm oscilloscope cameras. The magazine holds 50ft of unperforated 60mm recording paper, the whole width of which is available for recording.

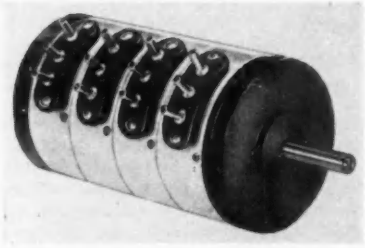


Two type of take-up cassette are available, a push feed for lengths up to 15ft and a power driven cassette for up to 50ft. Paper speeds, 0·02, 0·06, 0·2, 0·6, 2, 6in/sec may be changed during a recording, either by the speed change switch, or by electrical remote control.

A special feature of the camera is an automatic single frame advance, facilitating the taking of single sweep records. A built-in time marker exposes lines across part or the whole width of the paper at intervals of 1/25, 1/5, 1, 10sec, appropriate intervals are automatically selected by the speed change mechanism.

An *f*3·5 bloomed lens with adjustable diaphragm in focusing mount is fitted as standard, other lenses to special order.

EE 3755 *for further details*



PRECISION POTENTIOMETERS

(Illustrated above)

P. X. Fox Ltd., Hawksworth Road, Horsforth, Yorkshire.

THE range of potentiometers manufactured by P. X. Fox Ltd has been extended to include precision type potentiometers with servo mountings.

Types with the servo mountings are of a completely new design using high precision windings in a special alloy aluminium housing to ensure a high rate of heat dissipation while giving the previous low torque characteristics, and they are available in the following types:—

SF. of 1 1″in o.d. in single or any required number of ganged form, and resistance per winding of up to 50kΩ.

SG. of 1 586in o.d. again in single or any required ganged units of resistance per winding of up to 50kΩ.

SB. of 2 528in o.d. available as above in any required single or ganged form of resistance per winding up to 100kΩ.

Torque varies with the number of ganged units but ranges from 0·5g./cm.

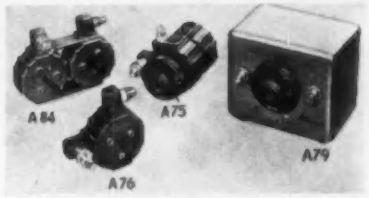
EE 3756 *for further details*

WIDEBAND ATTENUATORS

(Illustrated above right)

Advance Components Ltd., Roebuck Road, Hainult, Ilford, Essex.

THESE attenuators are a development the model A38, and employ resistive ladder networks at a constant impedance of 75Ω. The construction and switch mechanism is similar to the model A38 and the fixing centres have been maintained in the case of the models A75, and A76, so that replacement with the new models is simplified. Special attention has been given in the design to obtain good v.s.w.r. performance. The standard sockets accept Plessey Minor Plugs.



Type A75, consists of two ten position networks providing an attenuation range of 99dB in 1dB steps. The two sections are mounted with concentric spindles and the attenuation setting appears in a window on the control knobs.

Type A76, consists of one ten position network providing an attenuation range of 90dB in 10dB steps.

Type A79, consists of the type A75, mounted in a metal case and is suitable for bench use in the laboratory or for any l.f. video, r.f. or v.h.f. application where a separate screened coaxial attenuator is required.

Type A84, consists of two ten position networks providing an attenuation range of 99dB in 1dB steps. The two sections are mounted side by side as required for example in a signal generator.

EE 3757 *for further details*

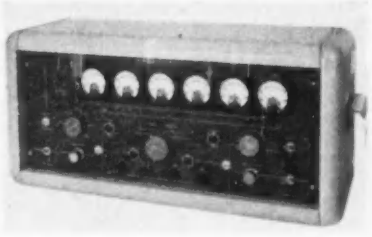
MICROSECOND STOPCLOCK

(Illustrated below)

Venner Electronics Ltd., Kingston-By-Pass, New Malden, Surrey.

THIS equipment, which uses transistors throughout, employs a new range of high speed counting stages to form a comprehensive time measuring equipment. The time range of the basic equipment is 3μsec to 1sec but this can be extended to 27·8h if required. The input impedance is 250kΩ and it can be arranged for single or two line working.

The equipment is capable of measuring pulse widths, mark to space ratios, period of pulse or other waveforms having amplitudes between 0·75V to 500V peak. Facilities are also embodied so that virtually any type of time measurement can be carried out on



contacts without the use of ancillary power supplies. The equipment is inherently self-checking on the applied waveform and has, in addition, six internally generated waveforms which are brought via a switch and emitter follower to a panel mounted socket.

The frequencies concerned are: 1Mc/s, 100kc/s, 10kc/s, 1kc/s, 100c/s, 10c/s.

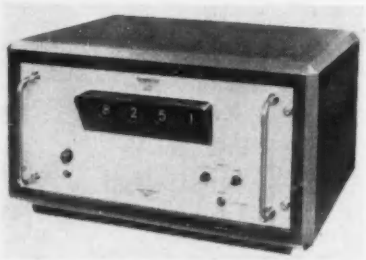
EE 3758 *for further details*

DIGITAL COUNTER

(Illustrated below)

J. Langham Thompson Ltd., Springland Laboratories, Bushey Heath, Hertfordshire.

J. LANGHAM THOMPSON LTD, have introduced a new digital counter incorporating several design features not usually associated with this type of instrument.



It is available in several forms to cater for different applications; it can also be supplied in a single form combining all these variations. Another interesting detail is the provision for up to two remote indicators.

The circuit employs the latest electronic techniques, and incorporates a crystal controlled cyclic timer with an accuracy of ±0·005 per cent. The counter is therefore very stable and has an overall accuracy of ±1 count.

Considerable attention has been paid to presentation and the brilliant neon display provides an in-line readout readable at 30ft.

The two versions of this instrument at present in production are a tachometer (see illustration), and a counter for random pulses up to 10kc/s.

EE 3759 *for further details*

PULSE HEIGHT ANALYSER

Sunvic Controls Ltd., 10 Essex Street, London, W.C.2.

THE prototype pulse height analyser shown by Sunvic Controls Limited at the Geneva 'Atoms for Peace' exhibition represents a considerable advance in flexibility of both arrangement and display. The instrument can be in the form of a desk type console measuring 62in × 29in × 40in approximately, or as one 6ft. or two 2ft 6in standard racks with display units at the top. Totals can be displayed in analogue form on a c.r.t., read in decimal form on Dekatron counters or automatically printed out.

A ferrite core storage matrix is used and provides 100 channels each with a maximum capacity of 16 binary digits (a decimal count of 65 535).

The measurement range is 10V with a channel width of 100mV. Minimum pulse amplitude which can be measured is approximately 0·75V.

When totals are displayed on the c.r.t. the six most significant digits are given in analogue form, horizontal deflexion being proportional to channel number and vertical deflexion to the counts in each channel. When the Dekatron indicators are used, any given channel can be selected or alternatively the instrument will read each channel in turn.

Unit construction, largely transistorized, is used, interconnexions being by multicore cables with plugs and sockets.

EE 3760 *for further details*

SERVO UNITS

(Illustrated below)

Servo Units Ltd., Farnborough Road, Farnborough, Hampshire.

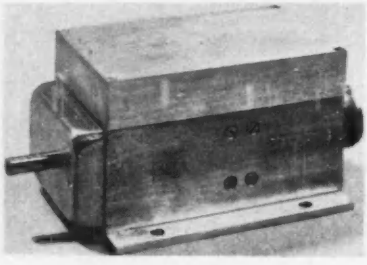
SERVO Units Ltd, the new subsidiary of Harvey Electronics Ltd. have produced an improved version of their servo units incorporating all the features of the earlier Harvey servos namely light weight, accuracy and high torque with the minimum of moving parts.

The previous version relied upon a vibrating relay to provide high torque without overshoot. In the new series the motor is fed via power transistors controlled either from a d.c. transistor amplifier or a thermionic amplifier supplied from a transistor h.t. supply all fed from the original d.c. supply. Mains a.c. supply units are also available.

The size of the smallest, type O.TR-6v, of these servos is 3·0in × 2·2in × 2·25 in, has a stalled torque of 1·0lb-ft. with a rate of response of 35°/sec, a repeatability of ±0·3 per cent full scale on light load and on 90 per cent full torque 2·5 per cent. Type 1.TR-12v is 4·10in × 2·55in × 2·50in, stalled torque 5·0lb-ft rate of response 50°/sec, repeatability ±0·3 per cent and under 90 per cent full load 2·0 per cent 360° rotation can also be provided.

The servos are available with various gear ratios giving up to twenty times the above speed of response with proportionately less torque. Gears are also available separately for experimental work in conjunction with a standard unit. The gear box unit is also available separately.

The replacement of the vibrating relay by power transistors makes these units considerably more attractive for industrial applications and for fields where minimum servicing is essential, e.g. computers, handling of radioactive materials, spinning and weaving, paper manufacturing, rubber processing or any automatic or semi-automatic process.



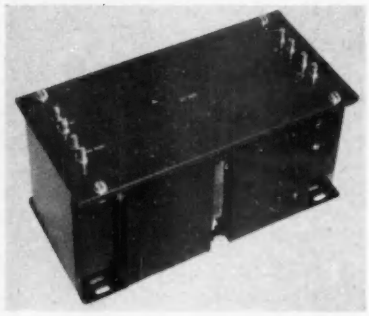
EE 3761 *for further details*

LINEAR SATURABLE REACTORS

(Illustrated below)

Haddon Transformers Ltd, Measons Avenue, Wealdstone, Middlesex

HADDON Transformers are now producing a range of linear saturable reactors up to 100kVA at unity power factor with wide range VA output and very low d.c. control power. The reactors are available in open or closed construction and may be processed to meet any climatic condition.



The 10kVA size, which is typical of the range, has an output VA at unity power factor of 3 to 91 per cent and requires a control power of 20W d.c.

EE 3762 *for further details*

MULTI-CHANNEL DIGITAL MILLIVOLT RECORDER

Bristol Aircraft Ltd, Filton, Bristol

THIS equipment will sample automatically 240 channels of thermocouples, recording on printed and punched paper tape, but can be used for voltage recording at all levels. The scanning system is entirely relay operated and digitizing is direct by a stepping potentiometer working with a 5-2-1-1 binary-coded-decimal step relationship. The detecting amplifier employs transistors and will operate at signal levels of 15μV. (This implies that the least significant of the three decimal digit presentations can correspond to 1/3°C for copper/constantan couples.) Alternative terminations in the form of typewriter or card punch may be used.

Many applications can be envisaged, from the collating of plant instrument data to the measurement of strains with resistive gauges.

The rates of operation are:

Punched card (3 channels/card) 60 channels/minute

Printed and punched tape 90 channels/minute

Typewriter punched tape 144 channels/minute

Punched tape 240 channels/minute

EE 3763 *for further details*

Notes from NORTH AMERICA

Digital Simulation for Speech and Television Research

According to several papers read at the recent Western Electronics Conference by members of the Bell Telephone Laboratories, the use of general purpose digital computers in the simulation of new coding and transmission devices shows promise of broadening and accelerating speech and television research.

Complex experimental apparatus must often be built to test theories or design concepts in speech and video research. This construction is costly and time consuming. In addition, in the experimental stage, it is frequently difficult to distinguish equipment errors from theoretical deficiencies.

Simulation of new devices by large scale digital computers can greatly reduce expense and time lags, and thus make it easy to investigate a large number of approaches to coding and transmission problems. It even becomes feasible to investigate highly speculative methods which might otherwise have to be ignored. One of the greatest virtues of simulation, however, is versatility, according to the authors, who emphasized that computers can simulate any explicit operation on a speech or video signal.

Drs E. E. David, M. V. Mathews and H. S. McDonald, all of Bell Telephone Laboratories, described the use of computers in speech research. Speech is sampled, each sample is quantized into 10 bits or 1 024 amplitude levels and delivered to a magnetic tape recorder. These coded samples are recorded in seven parallel tracks, with 200 characters to the inch of tape. These tapes are then fed into the computer, where they are processed according to pre-assigned programs based on the coding or transmission scheme being investigated. The processed signals are then re-recorded, decoded, and played back for analysis and listener evaluation.

Computer memory requirements for speech processing are severe due to the large amount of data generated by even a short section of speech. Rapid access memory units must have a capacity of several seconds of speech to be useful. For example, an 8 000 32-bit word memory can conveniently hold only about 2·4sec of speech, at a sampling rate of 10 000 ten-bit samples per second.

A speech transmission scheme known as the 'Extremal' method has been studied at Bell Laboratories extensively by simulation, and illustrates graphically the advantages of the new technique. In its simplest form, only the extremes, or peaks and valleys, of a speech wave are sampled. The amplitudes and time of occurrence of these points are then transmitted, instead of a detailed representation of the entire wave. At the receiver, an approximation of the speech wave is generated by interpolating a suitable mathematical function between these points.

Listener evaluation of the simulated speech produced in initial tests showed that intelligibility is high—above 90 per cent sentence intelligibility—but that the quality is somewhat below that of commercial telephones.

Digital simulation has been applied to a number of other speech problems at Bell Laboratories. These include the design and evaluation of delta-modulation coders, pulse - code - modulation systems, detection of vocal pitch, and automatic recognition of speech.

Picture coding research has also been carried on by computer simulation. Mr. R. E. Graham and Dr. J. L. Kelly of the laboratories described a technique which has been used to evaluate a number of proposed television coding schemes, and to improve others. In order to hold machine time and memory requirements to a reasonable level, their system has used an input picture of 100 × 100 elements, corresponding to an area about 1/25 that of a conventional television frame. This 10 000 element 'window' has proved to be of sufficient size to allow critical evaluation of the processed images. For typical coding schemes, the total computer time required is 5 to 10sec per picture.

A magnetic tape recording of the video signal is prepared by scanning a square picture with 100 scanning lines in 2·4sec. Each picture dot is quantized to 10-bit accuracy, providing 1 024 amplitude levels, and recorded in the same form as the speech samples described above. The resulting signal is rooted, mixed with a synchronizing waveform in the conventional manner, and band limited to 2·5kc/s.

In playback, the computed picture signal is converted back to analogue form. It is then passed through a low-pass filter, and displayed on a monitor with two kinescope tubes. One of these tubes has a slow phosphor for direct viewing, while the other has a fast phosphor for photography.

A coding scheme which may have widespread significance in television transmission, known as 'Predictive Quantizing', has been studied by both simulation and conventional methods by Mr. Graham. This scheme takes advantage of the relatively low level of viewer perception during periods of scene change or motion, and in areas of picture confusion, these being the only regions in which predictive coding systems make significant errors. The method involves quantizing the difference between the original continuous signal and a predicted version of that signal. It employs fine quantum steps for small errors, and coarse steps for large errors, where the predictor and the viewer are surprised. This tapering of steps in the quantizing staircase allows the use of a smaller number of total levels, and thus reduces the channel capacity requirements.

A limiting case of predictive quantizing, in which the predictor is simply a one-sample delay, has been tested both with the simulation equipment described and with standard 525-line television, and found to afford a picture not significantly degraded from the original, and requiring only three bits per picture dot.

Analogue Computer

A new analogue computer of advanced design, and known as the model 200 has been introduced by the Colorado Research Corporation.

The basic model 200 is enclosed in a console unit equivalent in size to three standard racks. Included in the console are the patchbay assembly, a 0·01 per cent reference voltage divider, a precision panel mounted valve-voltmeter, and all the indicating lights, internal wiring, power and logic controls essential to the operation of an analogue computer system.

A writing shelf, at convenient desk height, extends across the console unit. Occupying the centre of the shelf is a raised turret supporting the control panel which places all the computer control and monitoring switches at the operator's fingertips, and all indicators are centralized and readily visible.

The control panel of the model 200 computer offers many new features and is very flexible. Component selection for adjustment or monitoring is achieved by sequential address entry on a keyboard of ten keys. Projection type indicators display the selected address, and any selection of erroneous or fictitious addresses is immediately revealed through a change in indicator field colour.

Another keyboard on the control panel is used for sequential entry of potentiometer values in the servo set potentiometer system which is utilized in the 200 Computer series. This CRC developed potentiometer setting system involves no clutches and can set ten turn potentiometers to the nearest turn of wire in an average time of less than two seconds. Panel mounted projection indicators record a four place potentiometer setting selection, with field colour showing when the desired value has been set.

Automatic scanning of computer components is a built in capability of the 200 console, and the equipment is easily adapted to tape programming and readout. A choice of AMP patching systems is available, ranging from a 1600 contact unshielded board to a 3600 contact shielded system with a patchboard assembled from individual nylon blocks. Passive computing elements are mounted directly behind the patchbay, and may be enclosed in a temperature regulated oven at the customer's option.

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 26 November. Time: 6 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
The Annual General Meeting of the Institution and the Annual General Meeting of Subscribers to Brit.I.R.E. Benevolent Fund, followed by Presidential Address of Professor E. E. Zepler.

South Wales Section

Date: 12 November. Time: 6.30 p.m.
Held at: Glamorgan College of Technology, Treforest.
Lecture: Problems of Television Servicing.
By: E. A. W. Spreadbury.

South Western Section

Date: 25 November. Time: 7 p.m.
Held at: The School of Management Studies, University Street, Bristol 1.
Lecture: Electronic Transducers.
By: G. F. N. Knewstub.

South Midlands Section

Date: 28 November. Time: 7 p.m.
Held at: North Gloucestershire Technical College, Cheltenham.
Lecture: Television Recording.
By: P. J. Guy.

West Midlands Section

Date: 12 November. Time: 7.15 p.m.
Held at: Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton.
Lecture: Transistors in Television Receivers.
By: B. R. Overton.

North Western Section

Date: 6 November. Time: 6.30 p.m.
Held at: The Reynolds Hall, College of Technology, Sackville Street, Manchester 1.
Lecture: The Determination of Aspect by a Shipborne Radar.
By: E. L. Crouchman.

Merseyside Section

Date: 28 November. Time: 7 p.m.
Held at: The University Club, Liverpool.
Lecture: The First Transatlantic Telephone Cable.
By: F. Scowen.

BRITISH SOUND RECORDING ASSOCIATION

Date: 21 November. Time: 7.15 p.m.
Held at: The Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.
Lecture: The Design of Stereophonic Pick-up Cartridges.
By: Stanley Kelly.

THE INSTITUTE OF NAVIGATION

Date: 21 November. Time: 5.15 p.m.
Held at: The Royal Geographical Society, 1 Kensington Gore, London, S.W.7.
Lecture: Navigating Across the Antarctic.
By: George Lowe.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.

Ordinary Meeting

Date: 6 November.
Lecture: The Recognition of Moving Vehicles by Electronic Means.
By: T. S. Pick and A. Readman.

Measurement and Control Section

Date: 4 November.
Lecture: Operating Experience with a Transistor Digital Computer.
By: R. C. M. Barnes and J. H. Stephen.
and: A New High-Speed Digital Technique for Computer Use.
By: D. Eldridge.
Date: 18 November.
Discussion: Ferro-Electrics.
Opened by: L. A. Thomas.

Radio and Telecommunication Section

Date: 19 November.
Lecture: Television Recording: A Survey of the Problems and the Methods Currently in Use.
By: J. Redmond.
Date: 24 November.
Lectures: The Use of Dispersive Dielectrics in a Beam-Scanning Prism.
By: J. S. Seeley and J. Brown.
The Quarter-Wave Matching of Dispersive Materials.
By: J. S. Seeley.
Theory of Reflections from the Rodded-Type Artificial Dielectric.
By: A. Carne and J. Brown.

East Anglian Sub-Centre

Date: 17 November. Time: 6.30 p.m.
Held at: The Technical College, Cambridge.
Lecture: The ZETA Reactor. (Joint meeting with the Eastern Branch of The Institution of Mechanical Engineers.)
By: R. Carruthers.
Date: 24 November. Time: 6.30 p.m.
Held at: The Crown and Anchor Hotel, Ipswich.
Lecture: British Columbia-Vancouver Island 138kV Submarine Power Cable.
By: T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson.

Mersey and North Wales Centre

Date: 17 November. Time: 6.30 p.m.
Informal talk: The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering.
By: E. C. Cherry.
Date: 24 November. Time: 6.30 p.m.
Held at: Chester Town Hall.
Lecture: The Recognition of Moving Vehicles by Electronic Means.
By: T. S. Pick and A. Readman.

North-Eastern Radio and Measurement Group

Date: 3 November. Time: 6.15 p.m.
Held at: King's College, Newcastle upon Tyne.
Lecture: Some Case Histories of Business Computers in the U.S.A.
By: A. T. Starr.
Date: 17 November. (Time and place as above.)
Lecture: A New Cathode-Ray Tube for Monochrome and Colour Television.
By: D. Gabor, P. R. Stuart and P. G. Kalman.

North-Western Radio and Telecommunication Group

Date: 12 November. Time: 6.45 p.m.
Lecture: The Relation between Picture Size, Viewing Distance and Picture Quality, with special reference to Colour Television and to Spot-Wobble Techniques.
By: L. C. Jesty.

South-East Scotland Sub-Centre

Date: 4 November. Time: 7 p.m.
Held at: The Carlton Hotel, North Bridge, Edinburgh.
Lecture: Speed Control of Large Wind Tunnels, with particular reference to the R.A.E. 8ft × 8ft High-Speed Wind Tunnel.
By: L. S. Drake, J. A. Fox and G. H. A. Gunnell.
Date: 5 November. (Time and place as above.)
Lectures: Operating Experience with a Transistor Digital Computer.
By: R. C. M. Barnes and J. H. Stephen.
and: A Basic Circuit for the Construction of Digital-Computing Systems.
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Lecture: The Recognition of Moving Vehicles by Electronic Means.
By: T. S. Pick and A. Readman.

South Midland Radio and Measurement Group

Date: 24 November. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Birmingham.
Lecture: The development of a Guided Missile.
By: W. R. Thomas.

Rugby Sub-Centre

Date: 11 November. Time: 6.30 p.m.
Held at: Rugby College of Technology and Arts.
Lecture: A New Cathode-Ray Tube for Monochrome and Colour Television.
By: D. Gabor, P. R Stuart and P. G. Kalman.
Date: 26 November. (Time and place as above).
Lecture: Thermo-Nuclear Reactions.
By: S. Kaufman.

Southern Centre

Date: 5 November. Time: 7 p.m.
Held at: Southampton University.
Informal Evening: The Use of Transistors in Radio and Television.
Talk by: E. Wolfendale.
Date: 12 November. Time: 6.30 p.m.
Held at: The C.E.G.B. Offices, 111 High Street, Portsmouth.
Lecture: A Survey of Harbour Approach Aids.
By: A. L. P. Milwright.
Date: 19 November. Time: 6.30 p.m.
Held at: S.E.B. Showrooms, 17 New Canal, Salisbury.
Lecture: Colour Television.
By: C. J. Stubbington.
Date: 26 November. Time: 6.30 p.m.
Held at: R.A.E. Technical College, Farnborough.
Lecture: Operational Experience at Calder Hall.
By: K. L. Stretch.
Date: 28 November. Time: 6.30 p.m.
Held at: South Dorset Technical College, Weymouth.
Lecture: The Design of Transistors.
By: J. R. Tillman.

Western Centre

Date: 27 November. Time: 6.45 p.m.
Held at: Colston Hall, Bristol.
Faraday Lecture: Automation.
By: H. A. Thomas.

West Wales (Swansea) Sub-Centre

Date: 25 November Time: 6 p.m.
Held at: The Brangwyn Hall, Swansea.
Faraday Lecture: Automation.
By: H. A. Thomas.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 12 November. Time: 6 p.m.
Held at: Manson House, Portland Place, London, W.1.
Lecture: Some Applications of Control Technique in Astronomy.
By: P. Fellgett.
Date: 19 November. (Place as above) Time: 2.30 p.m.
Symposium on Analytical Instrumentation Developed at Harwell.
Date: 25 November. (Time and place as above).
Lecture: Digital Data-Recording for Nuclear Experiments.
By: R. C. M. Barnes.

THE TELEVISION SOCIETY

Date: 6 November. Time: 7 p.m.
Held at: The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.
Lecture. Advertising in Relation to Television.
By: D. Ingman.
Date: 21 November. (Time and place as above).
Lecture: The European Television Network—Some Operational Problems.
By: J. Treeby Dickinson.

PUBLICATIONS RECEIVED

RUSSIAN-ENGLISH GLOSSARY OF ELECTRONICS AND PHYSICS is a compilation of Russian terms used in the various specialized fields of electronics. It includes terms from the most recent issues of Soviet journals, including Automation and Remote Control, Journal of Technical Physics, Radio Engineering and Electronics, etc. To this has been added an appendix containing circuit notation, American equivalents for vacuum tubes, etc. Consultants Bureau, Inc, 227 West 17th Street, New York, 11. Price $10.

A GUIDE TO NUCLEAR ENERGY by R. F. K. Belchem attempts to explain to persons with limited specialist knowledge how nuclear reactors function, and includes a general description of the more important types now being constructed or studied. The survey includes a description of the constructional materials of importance to the nuclear energy industry. Sir Isaac Pitman & Sons Ltd, 39 Parker Street, Kingsway, London, W.C.2. Price 10s.

THE RADIO AMATEUR'S HANDBOOK, 35th edition, has recently been published by the American Radio Relay League, West Hartford 7, Connecticut, U.S.A. It is revised and restyled in the light of current needs as a radio construction manual, reference work, and training text for class or home study. Price $4.50.

WORKED RADIO CALCULATIONS by Alfred T. Witts, 2nd edition. In this revised edition the text has been adapted to the m.k.s. system of units with the object of bringing it into line with the recommended procedure for teaching in Technical Schools. Substantial additions have been made to the text to include calculations on a variety of radio receiver problems that the modern service engineer and radio student is called upon to solve. Sir Isaac Pitman & Sons Ltd, 39 Parker Street, Kingsway, London, W.C.2. Price 12s. 6d.

MESURE ET DETECTION DES RAYONNEMENTS NUCLEAIRES by J. Sharpe and D. Taylor is the French translation and adaptation by J. Chatelet of the books Nuclear Radiation Detectors and The Measurement of Radioisotopes published by Methuen and Co. in 1957. M. Chatelet is chief physicist at the Laboratoire National d'Essais. Dunod Editeur, 92 Rue Bonapart, Paris 6. Price 3 400F.

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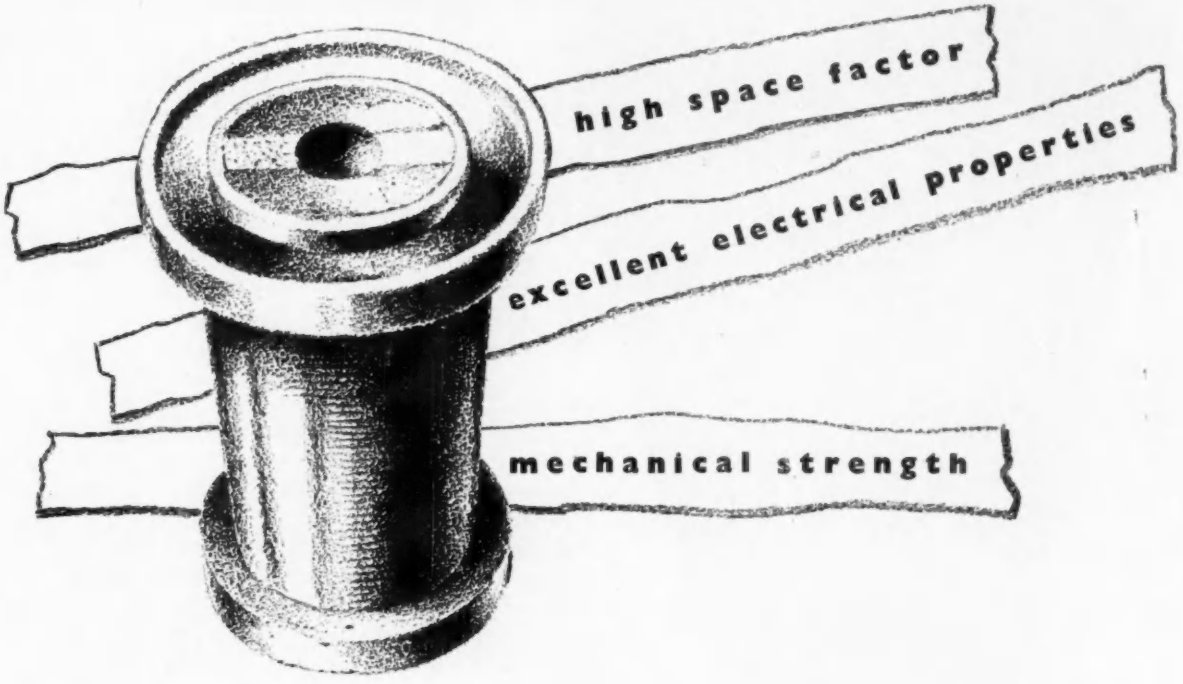

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Lecture: Operational Experience at Calder Hall.
By: K. L. Stretch.
Date: 28 November. Time: 6.30 p.m.
Held at: South Dorset Technical College, Weymouth.
Lecture: The Design of Transistors.
By: J. R. Tillman.

Western Centre

Date: 27 November. Time: 6.45 p.m.
Held at: Colston Hall, Bristol.
Faraday Lecture: Automation.
By: H. A. Thomas.

West Wales (Swansea) Sub-Centre

Date: 25 November Time: 6 p.m.
Held at: The Brangwyn Hall, Swansea.
Faraday Lecture: Automation.
By: H. A. Thomas.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 12 November. Time: 6 p.m.
Held at: Manson House, Portland Place, London, W.1.
Lecture: Some Applications of Control Technique in Astronomy.
By: P. Fellgett.
Date: 19 November. (Place as above) Time: 2.30 p.m.
Symposium on Analytical Instrumentation Developed at Harwell.
Date: 25 November. (Time and place as above).
Lecture: Digital Data-Recording for Nuclear Experiments.
By: R. C. M. Barnes.

THE TELEVISION SOCIETY

Date: 6 November. Time: 7 p.m.
Held at: The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.
Lecture: Advertising in Relation to Television.
By: D. Ingman.
Date: 21 November. (Time and place as above).
Lecture: The European Television Network—Some Operational Problems.
By: J. Treeby Dickinson.

PUBLICATIONS RECEIVED

RUSSIAN-ENGLISH GLOSSARY OF ELECTRONICS AND PHYSICS is a compilation of Russian terms used in the various specialized fields of electronics. It includes terms from the most recent issues of Soviet journals, including Automation and Remote Control, Journal of Technical Physics, Radio Engineering and Electronics, etc. To this has been added an appendix containing circuit notation, American equivalents for vacuum tubes, etc. Consultants Bureau, Inc, 227 West 17th Street, New York, 11. Price $10.

A GUIDE TO NUCLEAR ENERGY by R. F. K. Belchem attempts to explain to persons with limited specialist knowledge how nuclear reactors function, and includes a general description of the more important types now being constructed or studied. The survey includes a description of the constructional materials of importance to the nuclear energy industry. Sir Isaac Pitman & Sons Ltd, 39 Parker Street, Kingsway, London, W.C.2. Price 10s.

THE RADIO AMATEUR'S HANDBOOK, 35th edition, has recently been published by the American Radio Relay League, West Hartford 7, Connecticut, U.S.A. It is revised and restyled in the light of current needs as a radio construction manual, reference work, and training text for class or home study. Price $4.50.

WORKED RADIO CALCULATIONS by Alfred T. Witts, 2nd edition. In this revised edition the text has been adapted to the m.k.s. system of units with the object of bringing it into line with the recommended procedure for teaching in Technical Schools. Substantial additions have been made to the text to include calculations on a variety of radio receiver problems that the modern service engineer and radio student is called upon to solve. Sir Isaac Pitman & Sons Ltd, 39 Parker Street, Kingsway, London, W.C.2. Price 12s. 6d.

MESURE ET DETECTION DES RAYONNEMENTS NUCLEAIRES by J. Sharpe and D. Taylor is the French translation and adaptation by J. Chatelet of the books Nuclear Radiation Detectors and The Measurement of Radioisotopes published by Methuen and Co. in 1957. M. Chatelet is chief physicist at the Laboratoire National d'Essais. Dunod Editeur, 92 Rue Bonapart, Paris 6. Price 3 400F.

3 BIG FACTORS

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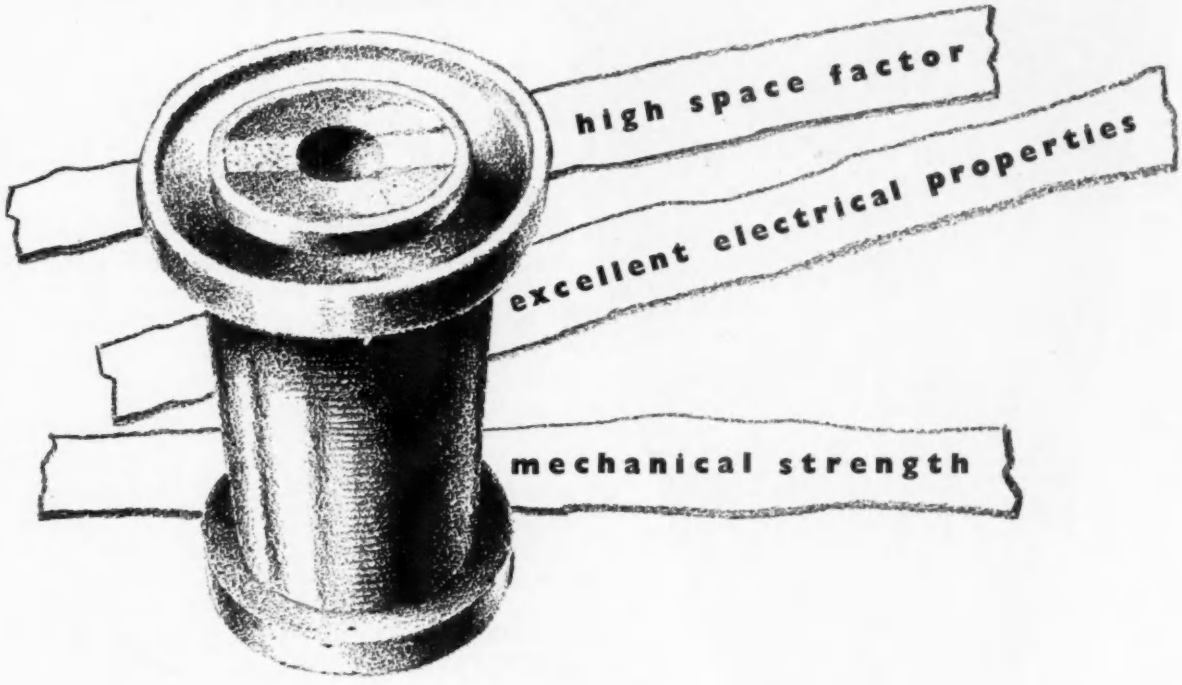

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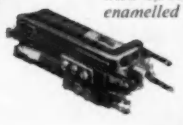
2 *Telephone Relay Coil wound with* 6,900 *turns of* ·0036 *inch enamelled wire.*



3 *Field Coil for motor car dynamo wound with* 280 *turns of* ·030 *inch enamelled wire.*

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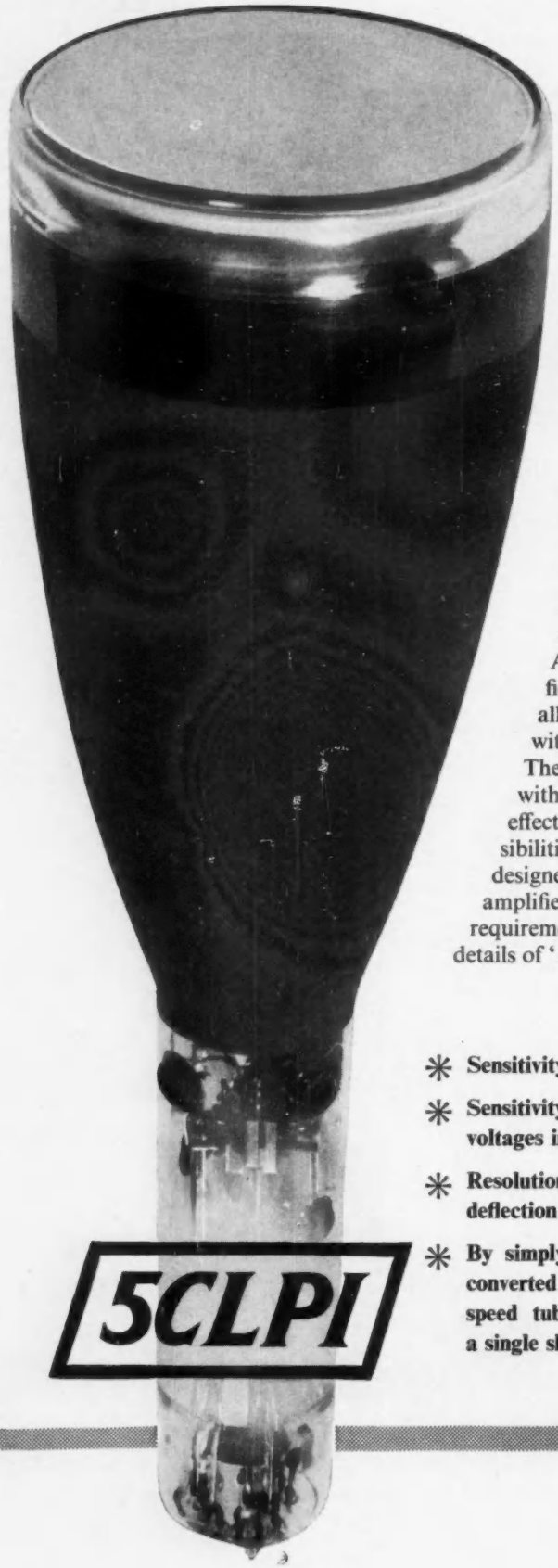

News!

One of the most important instrument tube developments in recent years is marked by the introduction by Electronic Tubes Ltd. of a unique 5-inch instrument tube. This tube, the 5CLP1, has a deflection sensitivity of 1.7 V/cm with a useful Y scan of 6 cm.

A new system of shielding the post deflection field from the deflection plates in the 5CLP1 allows p.d.a. ratios as high as 15:1 to be used without pattern distortion.

The extraordinary deflection sensitivity achieved with such high p.d.a. ratios will have a profound effect on oscillograph design. Among the possibilities that will immediately come to the mind of designers are wider bandwidths, simplification of amplifiers and the reduction of power supply requirements. Write to the address below for full details of 'ETEL' Instrument Tube type 5CLP1.

- **Sensitivity 1.7 V/cm with a useful Y scan of 6 cm.**
- **Sensitivity substantially independent of final p.d.a. voltages in the range 10 to 15 kV.**
- **Resolution is such that only 200 mV is required for a deflection of one spot-width.**
- **By simply altering one potential, the 5CLP1 may be converted from a very sensitive tube to a higher writing speed tube – pulses may be first examined and then a single shot photograph taken.**

News! News!

Post deflection shield gives latest 'ETEL' instrument tube A COMPLETELY NEW ORDER OF SENSITIVITY

Abridged Data for the 5CLP1

(This is tentative. Final data is being prepared)

5-inch flat face precision oscilloscope tube with side connections to the deflector plates and a distributed p.d.a. system.

CATHODE Indirectly heated ... $V_h = 6.3V$, $I_h = 0.55A$

SCREEN Phosphor types—P1, P7, P11. Metal backed.

DEFLECTION Double electrostatic. Intended primarily for symmetrical deflection.
Linearity: ± 2%
Pattern distortion: ± 2%
Orthogonality: ± 1°

CAPACITANCES

X_1 to X_2	2.5 pF
Y_1 to Y_2	2.0 pF
One X plate to all other electrodes less other X plate	4.0 pF
One Y plate to all other electrodes less other Y plate	2.0 pF

DIMENSIONS

Overall length ...	510mm max.
Face plate ...	133mm diameter
Base	B12F

TYPICAL OPERATING CONDITIONS

	1.	2.	3.	4.
V_{a5}	10kV	15kV	15kV	15kV
V_{a4}	10kV	15kV	15kV	3kV
V_{a3}	1kV	1kV	1.5kV	1kV
V_{a2} for focus	250V	250V	375V	250V
V_{a1}	1kV	1kV	1.5kV	1kV
Vg for cut-off	–60V	–60V	–90V	–60V
Deflection sensitivity y	1.7V/cm	1.7V/cm	2.5V/cm	2.5V/cm
Deflection sensitivity x	7V/cm	7V/cm	11V/cm	11V/cm
Line width	1mm	1mm	< 1mm	< 1mm
Useful screen area y	6cm	6cm	6cm	4cm
Useful screen area x	10cm	10cm	10cm	6.6cm

COMPARE CONDITIONS

1 and 2 to see how deflection sensitivity is maintained over range of V_{a4} and V_{a5}.

1 and 2 with 3 for an illustration of a slightly lower sensitivity condition giving higher brightness.

2 and 4 for the reduction required in V_{a4} potential to achieve higher writing speeds.

ETEL Registered Trade Mark **CATHODE RAY TUBES**

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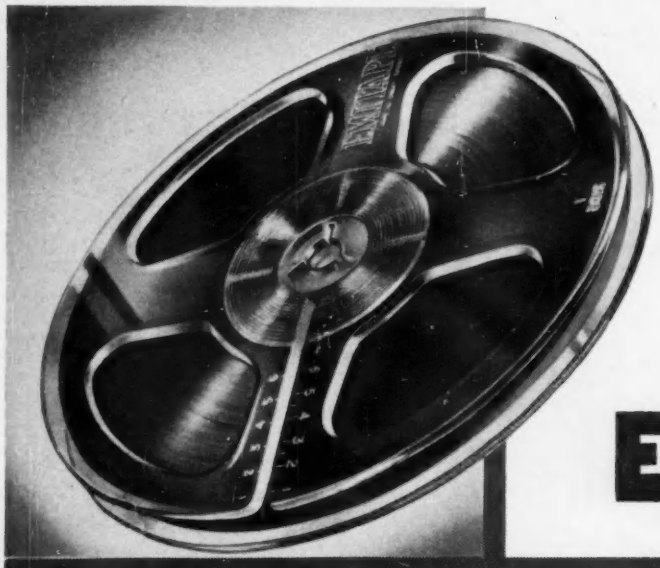

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Type No.	Title	Size	Length Approx.	Price
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99/3		3" dia.	250′	9 . 6
88/3N		3½" dia.	175′	7 . 6
99/3N		3½" dia.	250′	9 . 6
★88/6	"Junior"	5" dia.	600′	£1 . 1 . 0
★99/9		5" dia.	850′	£1 . 8 . 0
★88/9	"Continental"	5½" dia.	850′	£1 . 8 . 0
★99/12		5½" dia.	1200′	£1 . 15 . 0
★88/12	"Standard"	7" dia.	1200′	£1 . 15 . 0
★99/18		7" dia.	1800′	£2 . 10 . 0
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99/24		8½" dia.	2400′	£3 . 12 . 6

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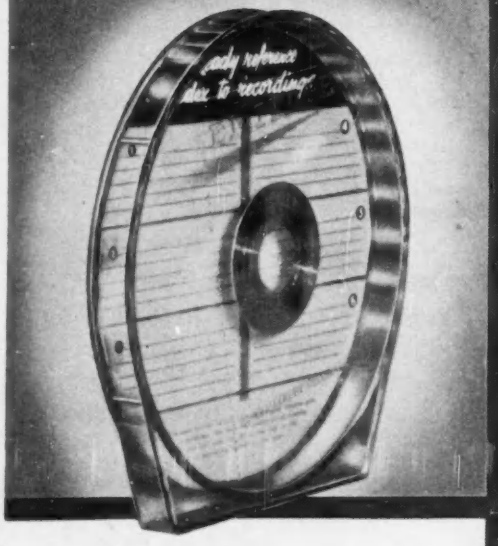

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- Jointing compound AP 35 for C.A. Base Tape
- Jointing compound AP 77 for P.V.C. Base Tape
- Non-magnetic scissors AP 39
- P.V.C. editing and marker tapes in a range of 6 colours AP 38/1-6
- Jointing tape AP 103

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- Emicase gives easy identification of leader tapes
- Has visible index
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Emicases: 5" 3/6—5¾" 3/6—7" 4/-

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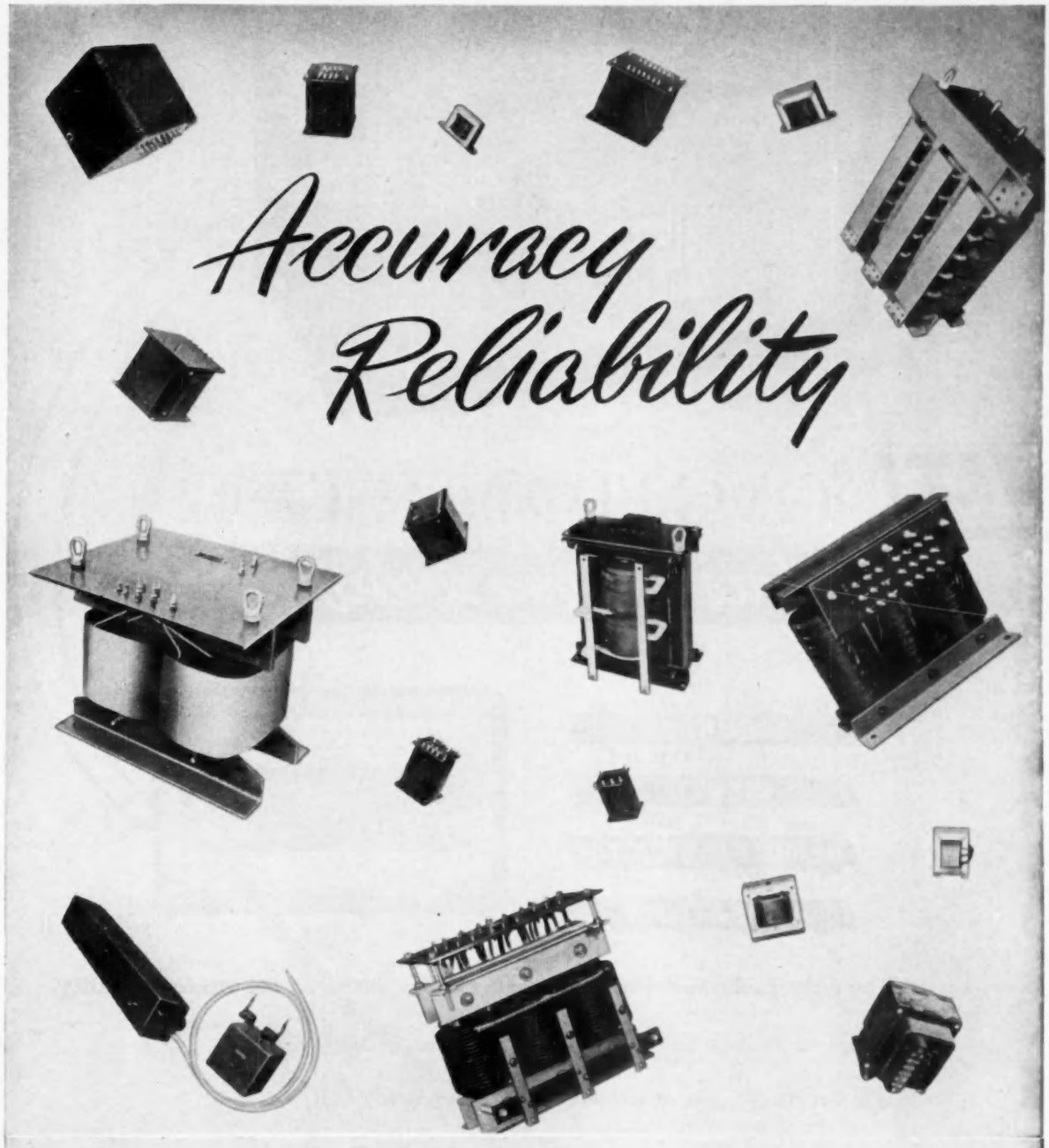

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The only Tachometer on the market today with remote readout facility.

Incorporates the latest brilliant neon in-line decade readout. Clearly visible at 30 feet. Three models are available, two of which have maximum counting rates of 10 Kc/s and the third up to 100 Kc/s. JLT Tachometers can be supplied in rack mounting form or housed in a *Datum* instrument case.

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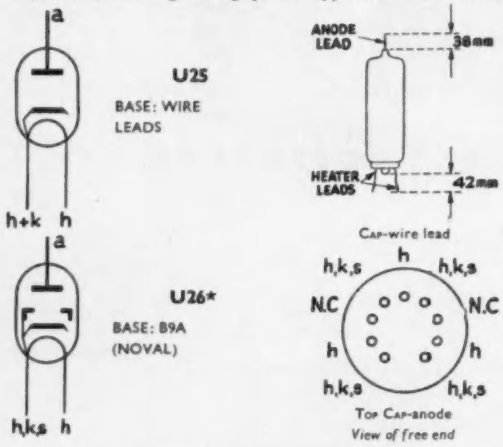
Introducing other outstanding Ediswan Mazda valves, types U25 and U26

For the information of set designers we are publishing details of individual 0.3 amp heater valves in our 'First Preference' Range for TV circuits. If you are a TV manufacturer, we shall be pleased to supply full technical details of our 'First Preference' Range together with a set of valves for testing, on receipt of your enquiry. The valves dealt with here are the Types U25 and U26, half wave rectifiers intended for use in "Flyback" or R.F. high voltage power supplies for Television Receivers.



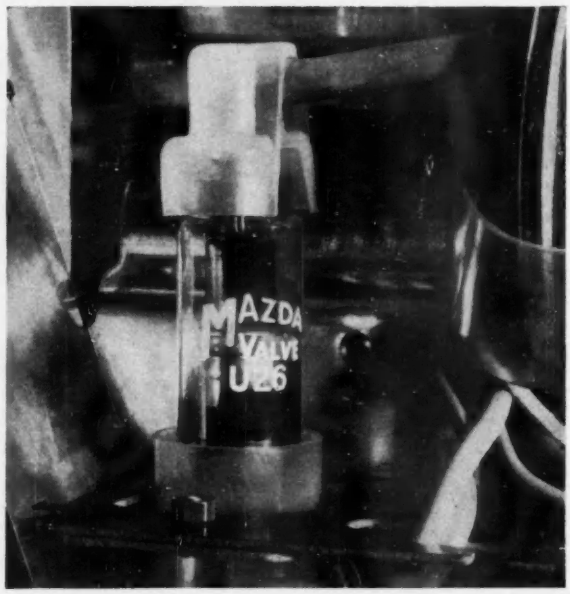
*Pins 3 and 7 marked N.C. have no internal connection but must not be left unconnected. They should be connected to the external circuit with not more than 100 V between adjacent pins.

		U25	U26
Heater Current (amps)	I_h	0.2	0.35
Heater Voltage (volts)	V_h	2.0	2.0

MAXIMUM RATINGS (Flyback Pulse)†

		U25	U26
Peak Inverse Voltage (Design Centre) (kV).....	$PIV_{(max)}$	19.0	23.5
Peak Inverse Voltage (Absolute) (kV)	$PIV_{(max)}$	22.0	27.0
Mean Anode Current (Design Centre) (mA)	$I_{a(max\ av)}$	0.2	0.2
Peak Anode Current (Design Centre) (mA)	$I_{a(max\ peak)}$	25.0	60.0

†Where the applied voltage pulse does not exceed 15% of one scanning cycle or 15μS duration.



With suitable circuits the U25 can be employed in television receivers to give d.c. output voltages up to 16kV. The U26 can give d.c. output voltages up to 18kV.

INTER-ELECTRODE CAPACITANCES (pF)

		U25	U26
Anode to heater and cathode	$C_{a\text{-}h,k}$	0.6	
Anode to heater, cathode and shield	$C_{a\text{-}h,k,s}$		0.9‡

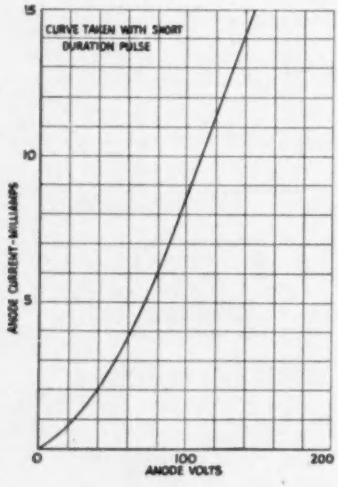
‡Total capacity including unscreened B9A ceramic holder, i.e., without can or skirt.

MAXIMUM DIMENSIONS

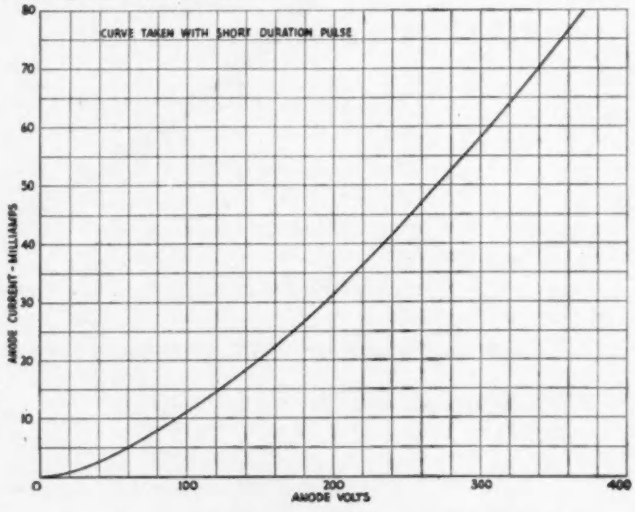
	U25	U26
Overall length (mm) (excluding leads)	58	
Overall length (mm)		76
Diameter (mm)	19	21
Seated height (mm)		69

Characteristic Curves of Average Ediswan Mazda Valves

Type U25



Type U26



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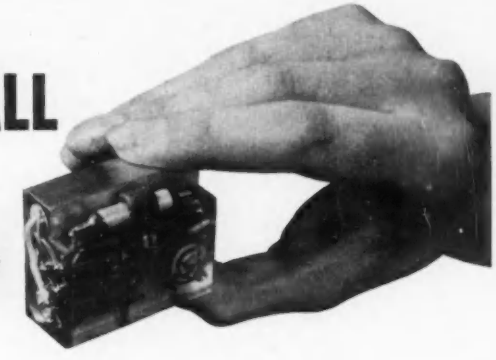

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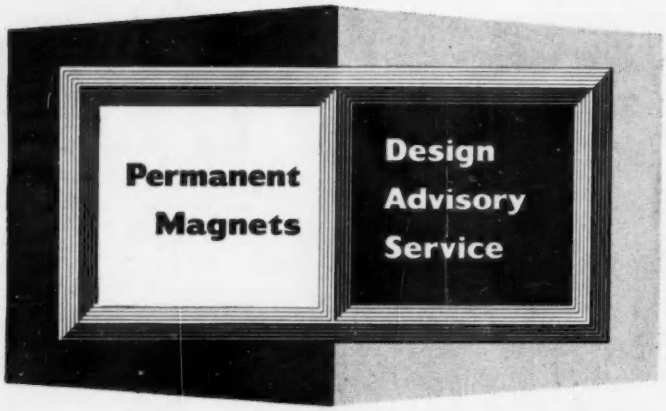


No. 8

Demagnetisation

Advertisements in this series deal with general design considerations. If you require more specific information on the use of permanent magnets, please send your enquiry to the address below, mentioning the Design Advisory Service.

There are two types of demagnetisation normally associated with permanent magnets. The first can be considered the controlled or precision reduction of the field for adjustment or stabilisation purposes. The second is the complete demagnetisation of the magnet to facilitate handling and assembly, and the avoidance of collecting magnetic particles.

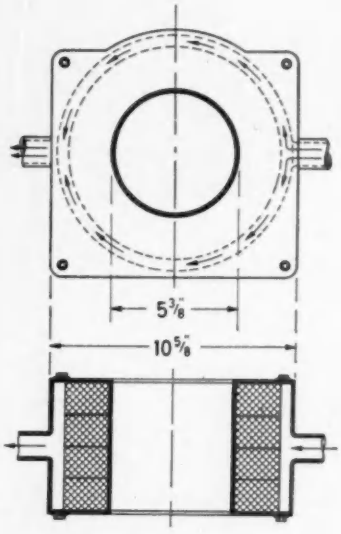
Providing the magnets are relatively small—that is—not exceeding about 2 lb. in weight, both methods of demagnetisation can conveniently be used with normal 50 c.p.s. power supply.

The first type of demagnetisation can be achieved in an accurately controllable a.c. field, usually by putting the magnet assembly into an air cored coil and controlling the a.c. supply by means of a variable transformer. If a very fine control is required for precision adjustment, a series choke with a movable iron core can be used to give infinitely fine adjustment of the field.

The second type of demagnetisation can be carried out in a similar manner, except that considerably more power is used. Generally it is found most convenient to connect the power supply direct to the coil and to move the magnetised magnets fairly slowly through the coil. Although theoretically, a field of 1,200 oersteds is sufficient for 'Ticonal' magnets, due to the screening effect of associated iron circuits the effectiveness of the field is considerably reduced, and the exact field requirements for this process cannot easily be calculated. The quickest method of finding the actual field requirements and current necessary, is by experimentation.

For 'Magnadur' magnets a demagnetising field in the region of 6,000 oersteds is necessary. An alternative method is to raise the temperature of the whole magnet past the curie point which is approximately 450°C., care should be taken to keep the temperature gradient small to avoid fracture of the magnet due to thermal expansion.

The demagnetisation of large magnets sometimes necessitates the use of lower frequency than 50 c.p.s. but as large magnets constitute unusual or special cases for which general instructions cannot easily be given, we would recommend engineers request assistance from our Design Advisory Service if they meet any unexpected difficulty.



Typical Air Cooled Demagnetising Coil

Technical details of coil:
Four sections each consisting of 75 turns of 12 s.w.g. D.C.C. wire arranged as shown and connected in series.

Supply:
400 volts 50 c.p.s. at 25 amps approx.

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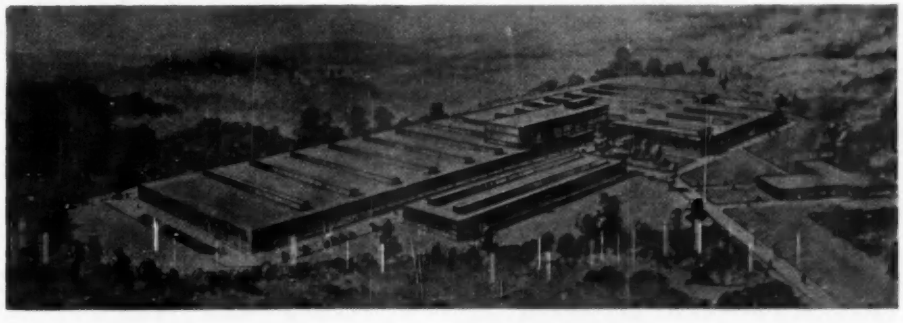
The vital need of our time is not merely to find or train scientists and technicians — but even more *to make the most fruitful use* of the brightest talent which this country already possesses. At Solartron we have no doubt of our responsibility and opportunity to create a "climate" in which Britain's finest brains, can create without inhibition and develop their fullest potential. In the following pages is a very brief look at some current Solartron product-line activities—all developed in the Group's young history from modest origins—the first evidence that the "Solartron philosophy" puts creative energy to work. If "philosophy" and "climate" seem to be mere intangible words, look too at the further evidence of the exciting new fields of progress in which Solartron are taking the lead. The *practical* structure in which we try to build this "permissive" Solartron philosophy is well worthy of study by any thinking engineer who would like his ability to make the highest contribution to the future—including his own! Solartron is an organisation of self-contained companies, each comprised of several small close-knit teams of very high calibre, able to put real impetus behind their chosen project, in a stimulating atmosphere where achievement is obvious and rewarded. In this structure, an engineer with a live contribution to offer will not only find opportunity from our steady growth into new fields, but unimpeded advancement for himself based on his technical achievement and ability to carry responsibility. And what does this mean to the *user* of Solartron equipment? It means 'expect the best from Solartron'! Solartron intend to lead. One way to assure this is to make the best use of the best brains.



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Industrial and scientific progress everywhere has been furthered by the superb quality of Solartron instruments, which include: unique *Dynamic Analysis Equipment* for rapid evaluation of control elements and systems—even under conditions of bad interference; *Communications Test Instruments* for the measurement, control and generation of test signals; *Metering & Pulse Equipment* having wide application in T.V., computer and data processing research; highly stable *Power Supplies*, conventional or transistorised, for bench or rack mounting — or in 'packaged' form for direct incorporation into production equipment.

ERA (Electronic Reading Automaton)

An artist's impression of an E R A of the type now in production. Reading up to 300 printed or typed characters per second direct from original business documents, E R A opens up fascinating new fields for data handling – computers are no longer restricted by cost and physical effort of feeding information by human operators. A famous chain of chemists shops has purchased E R A to read, at head office, cash register rolls from their 1300 branch stores, for rapid automatic analysis.

CYBERNETICS

Future development of Solartron learning and teaching machines will enable us to learn what is going on in complex industrial systems and teach optimum combinations of processes and controls. Present applications are being used to teach keyboard skills in a Government department.

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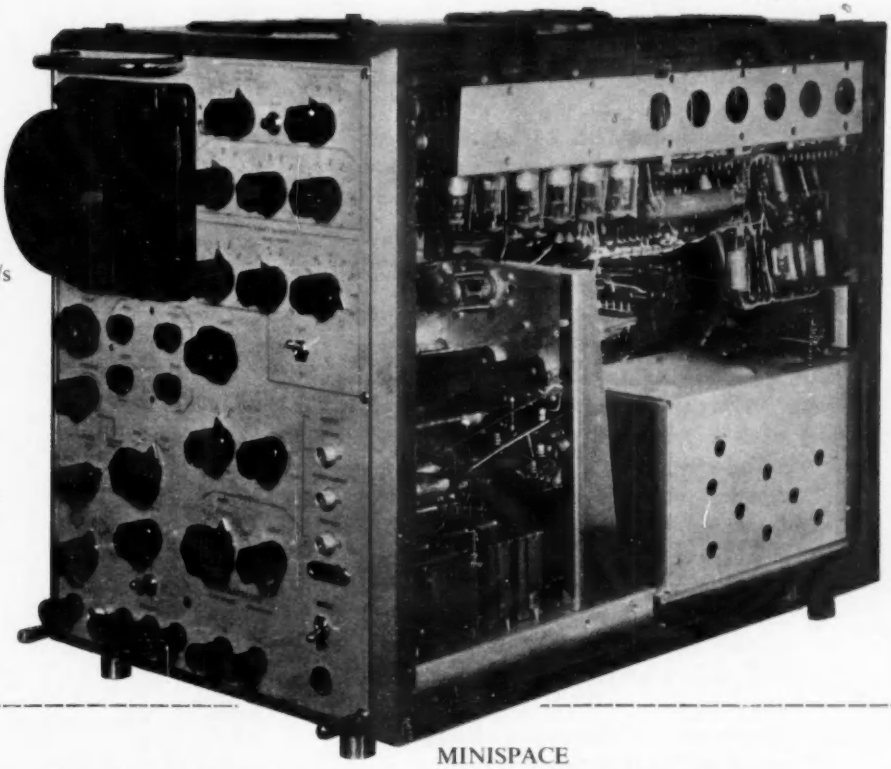
OSCILLOSCOPES

The CD 643·2 Solarscope illustrated is the most accurate measuring oscilloscope in production. It has a constant-bandwidth of D.C. to 12 Mc/s with Y signal delay, improved time base facilities, and measurement to better than 2%, on both signal and time axes.
This is one example from a world famous range of oscilloscopes covering every application of rapid visual analysis, and based on intensive study of user requirements.
Solarscopes in wide Interservice front-line use have passed the most gruelling tests prescribed for Joint Service Approval.



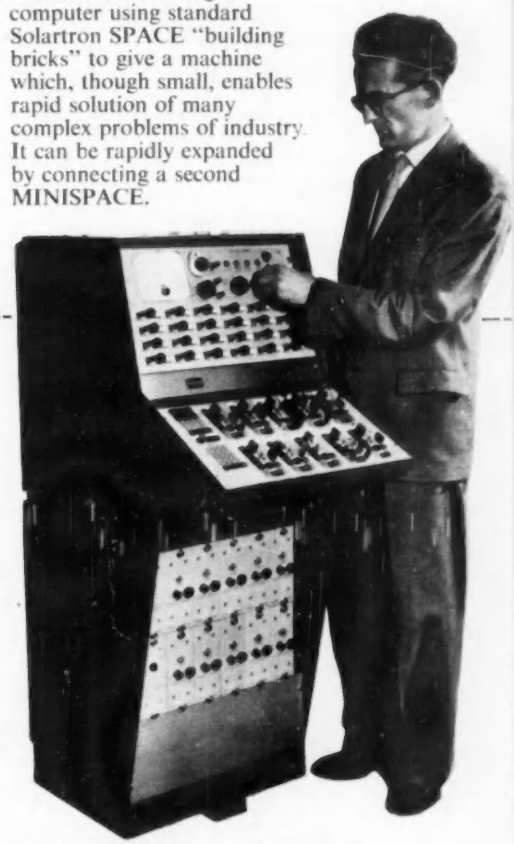
COMPUTERS

The Solartron precision range of computing "building bricks" provides these three approaches to analogue computer or simulator installation: (a) Complete capital equipments may be ordered, tailored to specific requirements. (b) Existing computers or simulators may be simply and quickly expanded. (c) A small pilot equipment may be bought initially, to be expanded from time to time as needed and in phase with improvement of purchasing power. The range of available units is wide, allowing the most complex machine to be built up while retaining flexibility of operation.

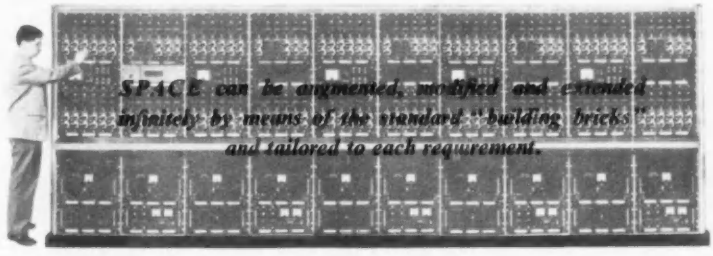
DATA HANDLING

Solartron offer interesting developments in the data-handling field. Current activities include such vital equipment as "Datatape" for recording dynamic information from missiles in flight.

MINISPACE
A completely new conception of a desk-side analogue computer using standard Solartron SPACE "building bricks" to give a machine which, though small, enables rapid solution of many complex problems of industry. It can be rapidly expanded by connecting a second MINISPACE.



SPACE (Solartron Precision Analogue Computing Equipment)


SPACE can be augmented, modified and extended infinitely by means of the standard "building bricks" and tailored to each requirement.

THAMES DITTON · SURREY · ENGLAND

INDUSTRIAL CONTROL SYSTEMS AND AUTOMATION

Solartron Industrial Controls Limited – a member Company of the international Solartron Electronic Group – offers a comprehensive consultancy service to industry, covering every application of control engineering.

Skilled systems engineers will advise on the planning and installation of complete, integrated, control systems. Experienced teams of specialists are ready to apply the most advanced design techniques – and rapid production is assured by the Group's substantial manufacturing resources.

Whilst the special knowledge available covers the whole field of process control and systems engineering, major project teams are at present based primarily on the following areas of application:—

i) Nuclear reactor instrumentation, including radiation monitoring and programmed hydraulic servo controls.

ii) Process and packaging control with special reference to continuous high-accuracy analysis and high-speed check weighing.

iii) Automatic and supervisory control based on multiple-loop feedback, using presentation devices ranging from chart recorders to digital and printing-out displays.

iv) Continuous non-destructive testing to fine limits, for quality control in flow-line manufacturing processes.

v) Continuous data analysis and integrated feedback control; synthesis of operations by electronic simulators.

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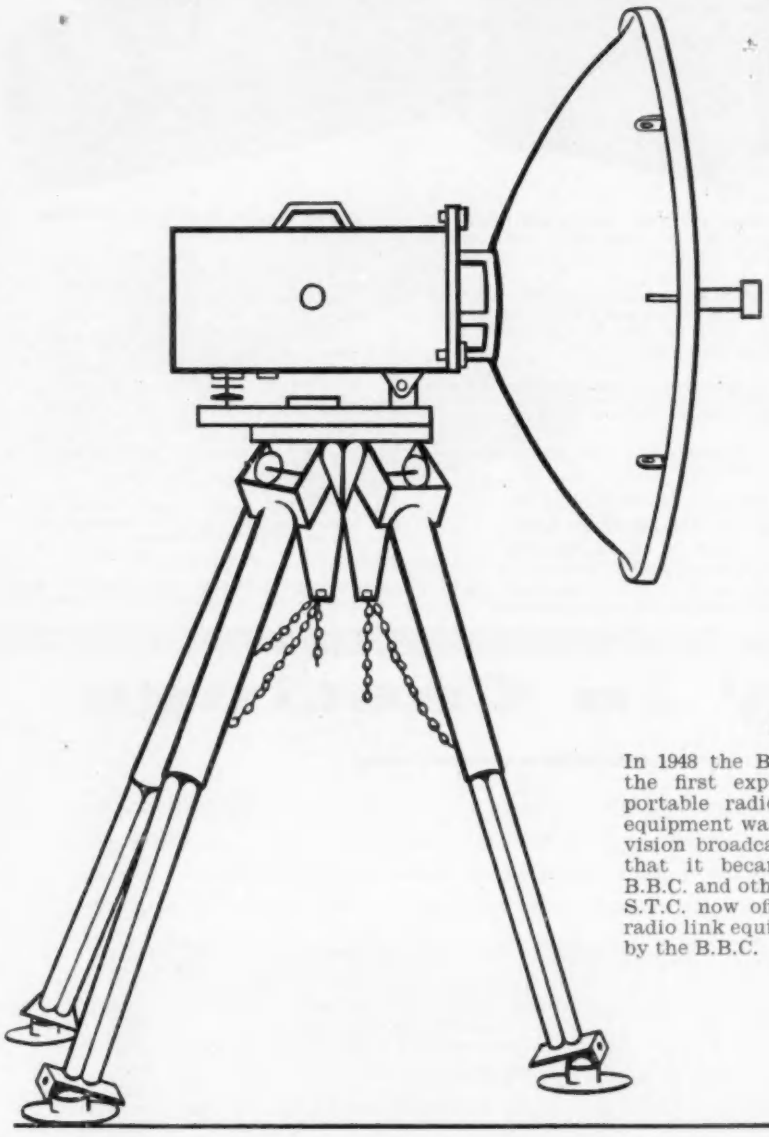
EE 3102 *for further details*

The *Standard* 7000 Mc/s Portable S.H.F. Link



- ***Suitable for 405-, 525- or 625-line, monochrome or colour, television picture transmission.***
- ***CCIR Approved I.F. frequency of 70 Mc/s.***
- ***Highly efficient electrical screening allows working on same mast as high-power television transmitter.***
- ***High-frequency stability without A.F.C. circuits.***
- ***New light-weight aerial with waterproof transmit and receive head units.***
- ***No forced air cooling in head units.***
- ***Has built-in lining-up equipment.***
- ***Range 30 to 40 miles. Extended by connecting a limited number of links in tandem.***

In 1948 the B.B.C. began extensive trials with the first experimental models of the S.T.C. portable radio link. Two years later similar equipment was used for their first outside television broadcast and performed so successfully that it became standard equipment for the B.B.C. and other television authorities.
S.T.C. now offer another new and outstanding radio link equipment which has also been chosen by the B.B.C.

Chosen by the B.B.C.

S.T.C. engineers can advise on all problems concerning radio links for both television and telephone transmission.

Standard Telephones and Cables Limited

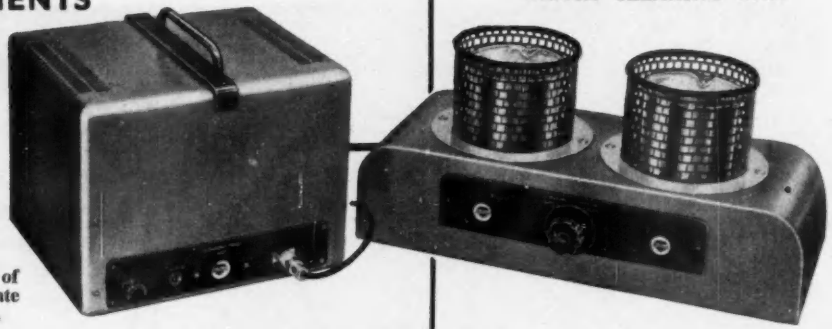
Registered Office: Connaught House, Aldwych, London, W.C.2

TRANSMISSION DIVISION: NORTH WOOLWICH · LONDON E.16

EE 3103 *for further details*

Ultrasonic Cleaning
OF SMALL COMPONENTS

CUTS CLEANING TIMES
REDUCES REJECTS
IMPROVES FINISH OF PRODUCT



If good cleaning is part of the quality of your product—you need to investigate the advantages of Ultrasonic cleaning.

Illustrated above is the Mullard general purposes intermediate power and frequency equipment designed for multi-stage cleaning of intricate components where a high degree of cleanliness is required. Facilities for rough washing and fine rinsing are housed on a single plinth.
The equipment can be supplied with either stainless steel or glass containers, allowing the use of a wide range of cleaning solutions, for tackling many kinds of contamination. A self-contained filtration unit, filtering down to approximately 1 micron, is available for removing suspended particles from the solvent.

Kerry's (Ultrasonics) Ltd

Also Ultrasonic Drilling, Soldering, Engraving, Threading and Lapping Equipment. Custom built high power hand dip and conveyorised Ultrasonic cleaning installations.

Write for complete technical details and a demonstration on your premises.

Sole Distributors in U.K. OF LOW POWER ULTRASONICS BY and certain overseas territories
MULLARD EQUIPMENT LTD.
One of the MULLARD Group of Companies
"MULLARD" is the trademark of Mullard Limited

The MULLARD BENCH CLEANING UNIT

is indispensable for the ULTRASONIC Cleaning of

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★ *A specialist company entirely devoted to bringing YOUR Industry the advantages of Industrial Ultrasonic Techniques.*

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Safety in Castings

The demands of modern science and the risks taken by individuals in probing the unknown depths of electronic and nuclear research, necessitate the greatest care being taken to ensure that every item of equipment is as perfect as man can make it. Impregnation of porous castings has now become an acclaimed method of salvaging castings which would otherwise be scrapped, thus saving costly machining time and man-hours. This is especially so in the aircraft industry where the design is limited by the weight and size factor, and consequently porosity is commonplace.

It is not only suitable for reclaiming castings which are required to be pressure tight, as it is a wonderful safeguard against atmospheric conditions where electronics are concerned; similarly in the field of nuclear energy as a safety precaution. Again, it can be used as an anti-corrosive material.

No casting is too large, no quantity is too small, and every type of metal can be treated. The process is swift and inexpensive, but for further details write to us, or alternatively, let us send one of our engineers who will gladly advise without obligation. Approved by Admiralty, M.O.S., A.I.D., A.R.B.

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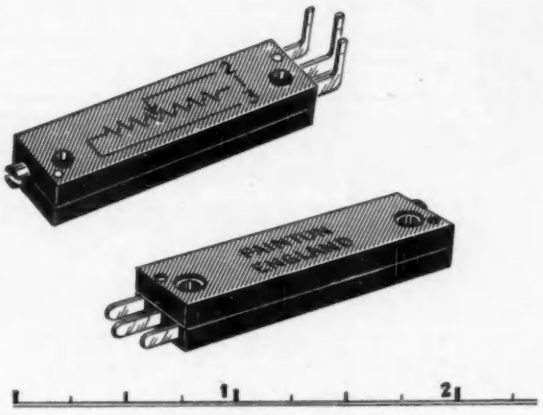
OLDHAM: 45, Roscoe Street, Tel: Main 5350.

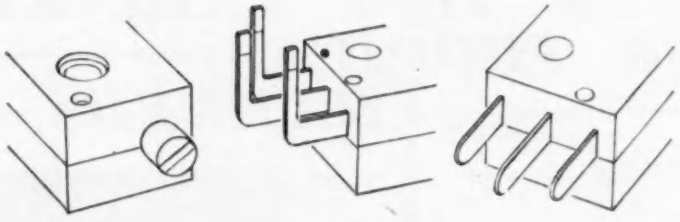
OVERSEAS: Impregnaciones Industriales S.A. Madrid & Barcelona.

EE 3123 *for further details*

THE NEW 'FLATPOT' POTENTIOMETER

This most recent addition to the comprehensive range of Painton potentiometers provides the electronic industry with a robust subminiature component that has been developed primarily for use with printed circuits, although its general design makes it eminently suitable for a wide range of applications; it is particularly useful where conditions of vibration pose problems for the design engineer. Its unusual 'linear' construction simplifies mounting and stacking where chassis space is at a premium.





The potentiometer winding, slider and drive are totally enclosed by a nylon filled plastic housing.

The slider is driven by a lead screw, whose head projects from the housing, permitting fine adjustment and resulting in stable settings.

The unique construction ensures rigidity and strength and minimises the likelihood of oxidation of the contact surfaces.

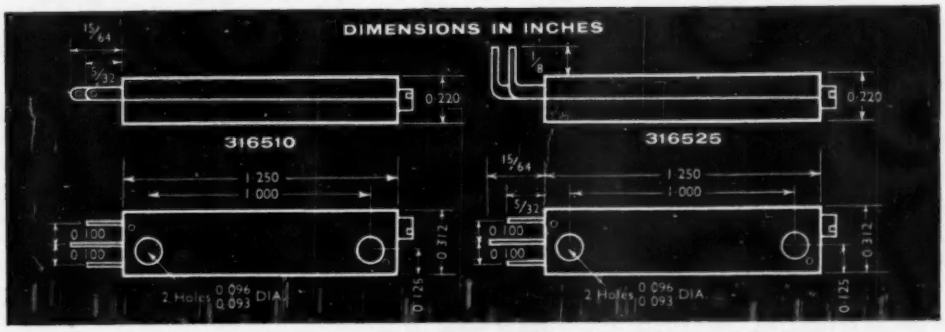
Damage to the mechanism by overwinding is obviated by a slipping nut device.

Straight or 90° terminals are available.

Gaps between terminals and distance between the two locating holes conform to the 0.1 inch module common in printed circuit boards.

Range: 10 Ω to 10K Ω
Tolerance: 10%
Power Rating: 1 watt at 20°C ambient
No. of turns from Zero to maximum resistance: 25
Insulation Resistance: in Excess of 1000M Ω
Weight: 0.1 oz. (approx.)

Write for technical leaflet



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KINGSTHORPE NORTHAMPTON
Tel: 32354/7 Telegrams: 'Ceil, Northampton'

EE 3103 *for further details*

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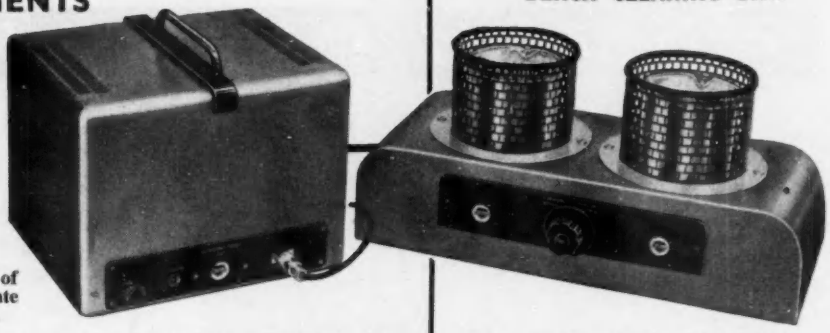

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EE 3123 *for further details*

EE 3104 *for further details*

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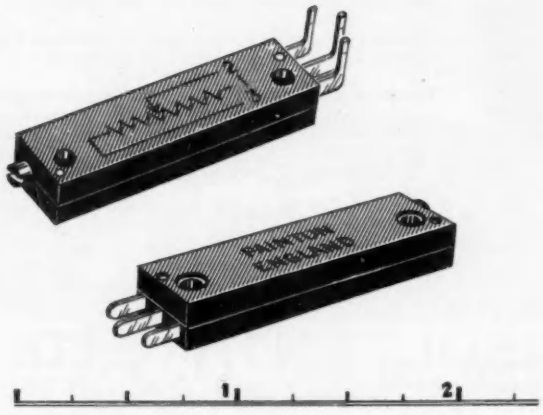

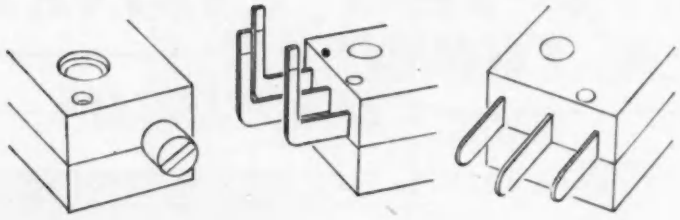

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The slider is driven by a lead screw, whose head projects from the housing, permitting fine adjustment and resulting in stable settings.

The unique construction ensures rigidity and strength and minimises the likelihood of oxidation of the contact surfaces.

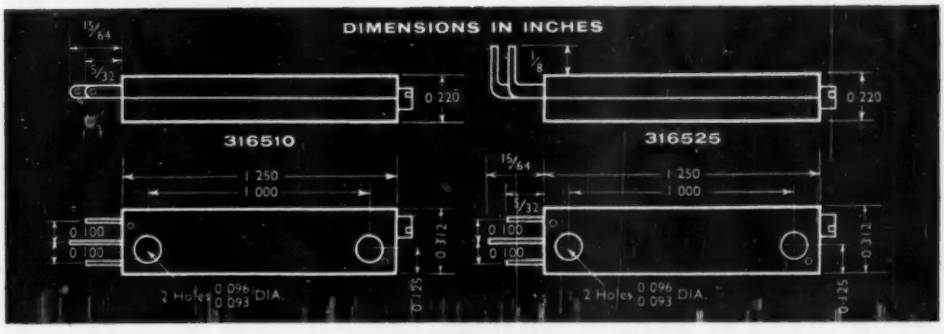
Damage to the mechanism by overwinding is obviated by a slipping nut device.

Straight or 90° terminals are available.

Gaps between terminals and distance between the two locating holes conform to the 0.1 inch module common in printed circuit boards.

Range: 10 Ω to 10K Ω
Tolerance: 10%
Power Rating: 1 watt at 20°C ambient
No. of turns from Zero to maximum resistance: 25
Insulation Resistance: in Excess of 1000M Ω
Weight: 0.1 oz. (approx.)

Write for technical leaflet



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AUTOMATIC NYQUIST DIAGRAM PLOTTER

This instrument has been specially designed to speed up the development and production testing of servo mechanisms and control systems. It is entirely self contained and consists of low frequency generator, accurate phase meter and amplitude detector. A complete Nyquist frequency plot is printed automatically in few minutes. Any adjustment to the control system can be, therefore, speedily checked by printing of a new Nyquist diagram.

EXCLUSIVE FEATURES:-

Electrical output signal at test frequency for testing of DC actuated servo systems and networks.

Modulated carrier output signal—available for direct application to AC operated servo systems.

Mechanical output allowing for direct connection to a hydraulic or pneumatic servo mechanisms eliminating errors introduced in electromechanical actuators.

Frequency range .3 c/s to 100 c/s.

Insensitive to harmonic distortion introduced by the system under test.

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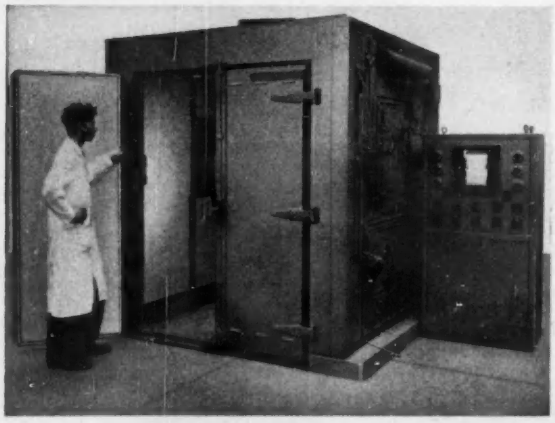

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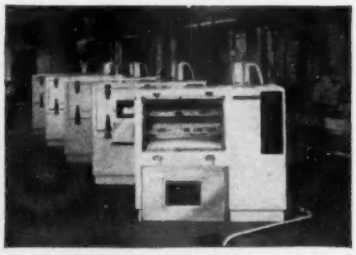

Group of small "B-W" Testing Cabinets for components and sub-assemblies is illustrated above (photo by courtesy of Nash & Thompson Ltd., Chessington, Surrey.)

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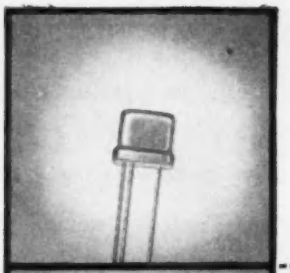
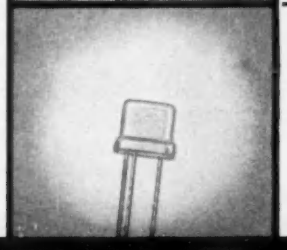


RF TYPES

	Min. f_α
6 Volts V6/R8	8 Mcs.
6 Volts V6/R4	4 Mcs.
6 Volts V6/R2	2 Mcs.

Excellent general purpose R.F. transistors which are finding increasing uses in switching circuits. Have useful current gains at high pulse currents and can be selected for 15 and 30 Volt operation. Maximum dissipation now 75 mW; 125 mW on a heat sink. Clips supplied free.



AUDIO TYPES

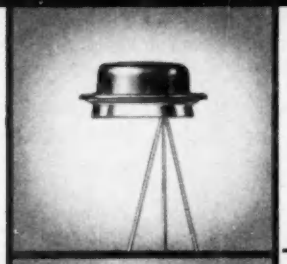
	Min. Beta
10 Volts V10/50B	50
10 Volts V10/30A	30
10 Volts V10/15A	15

An ideal transistor for audio stages of portable receivers. Maximum dissipation now 125 mW; on a heat sink 200 mW. Clips supplied free. Selected types for 30 Volt operation can be supplied to order.

Newmarket GOLTOP* Transistors

NOW **4** RANGES IN PRODUCTION

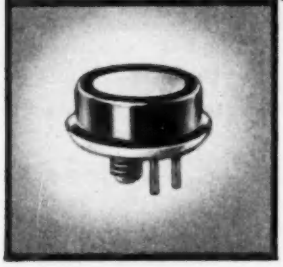
ALL TRANSISTORS ACTUAL SIZE



INTERMEDIATE POWER

Volts		Min. Beta 20
15	V15/20IP	
30	V30/20IP	

With maximum power dissipation of 2 watts, this transistor fills the gap between the audio types and the 10 watt power types in both power output and frequency range. Excellent for low-power transmitters at frequencies up to 500 kc/s. Sealed by cold welding and supplied with special clip mounting, eliminating large fixing studs. 60-Volt types can be selected to order.



POWER

	Minimum Beta		
Volts	10	20	30
15	V15/10P	V15/20P	V15/30P
30	V30/10P	V30/20P	V30/30P
60	V60/10P	V60/20P	V60/30P

The widest range of power transistors available with the closest tolerances. Extremely robust, reliable and stable. High heat dissipation—up to 20 watts per pair used in Class B with suitable heat sink. Up to 80 watts per pair obtainable in Inverter applications. Matched pairs can be supplied.

Leading the way With four years manufacturing experience behind us we are still expanding our production, still increasing our efficiency by new techniques in mechanisation. This policy ensures that the latest developments in transistors will always be offered by Newmarket at extremely competitive prices. The special requirements of every customer receive individual attention.

* *Identified by the gold top.*

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Telephone: Newmarket 3381-4 Cables: Semicon Newmarket

EE 3108 *for further details*

"He's a very live wire"

they warned.

"I can keep him on the straight and narrow"—
Vidaflex sounded confident.

"Goes round and round in circles," they explained.

"Then I'll go with him—I'm really flexible." Vidaflex sounded keen.

"You might burn your fingers," they warned,
"he's a very hot customer in a very tight spot."

"His heat must be dissipated," Vidaflex said firmly
"and anyway, I'm flame-proof!"

"Will you wear make-up?" they asked curiously.

"A touch of silicone varnish, perhaps"
Vidaflex answered loftily.

At that there was a brilliant flash,
a puff of smoke—and a very
thoughtful electrical engineer
found himself holding a
braided sleeve of Vidaflex.
"I think this is just the job" he
announced to his testing bench.

Vidaflex flexible glass sleevings
are braided from **FIBREGLASS**
and made exclusively by
Jones Stroud and Company Ltd.

If you'd care to meet the whole family of

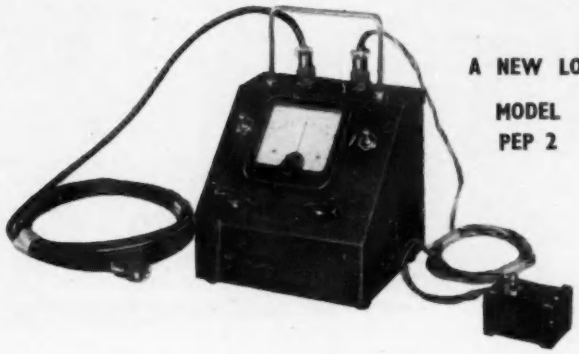
JONES STROUD sleevings

write for a catalogue to HIGHFIELD MILLS, CANAL ST., LONG EATON, NOTTINGHAM.

Aids to the use of

NAGARD LTD

OSCILLOSCOPES



A NEW LOW FREQUENCY VIBRATION PICK-UP — 0–500c/s.

MODEL PEP 2

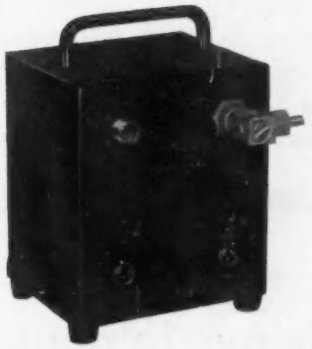
Complete with control box and energising batteries. Operating on a new principle using photo electric transistors, this compact device gives a linear voltage up to 2.5 mm. displacement with a sensitivity of 0.5 volts/mm. Easily applied to vibrating objects, and going down to zero frequency it is easily calibrated.

Used with a Nagard Model DT103 Two Channel Oscilloscope, a complete analysis of relative vibrations, including phase, resonance, damping, frequency and wave-form is possible with ease and accuracy.

AN ELECTROMETER INPUT STAGE — MODEL 2502

For use where the signal source may not be loaded, as in electro-physiology, or where the source impedance is high, as with some types of crystal pick-ups, this cathode follower stage provides an input resistance of 10,000 megohms and covers a frequency band from DC up to 100 Kc/s.

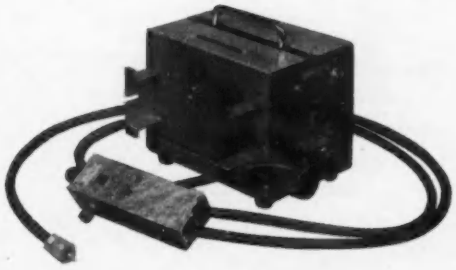
Used with a Nagard DT103 Oscilloscope, which has a sensitivity of 250 μV/cm, this is a valuable aid to work with small signal levels.



MODEL 1802 HIGH FREQUENCY CATHODE FOLLOWER PROBE

For applications where the signal source may not be disturbed by added capacity, and particularly where high frequencies are encountered, this provides a mains driven self contained unit with the probe at the end of 3 feet of cable, and may be used with any suitable oscilloscope, particularly the Nagard DE103A wide band model.

A transient response faithful from DC to 15 Mc/s without ringing or overshoot is provided through an input capacity of 10$\mu\mu$F. Attenuator in ratios of X1 and X30 is built in to the probe, which will handle voltages up to $\pm$500.



MODEL 2701 HIGH DISCRIMINATION PRE-AMPLIFIER

For the elimination of in-phase voltages, such as A.C. hum, this provides a balanced input pre-amplifier giving alternative gains of X10 or X100 and is self contained with mains driven power unit.

The rejection ratio can be as high as 10,000-1 and adjustments are provided to suit a variety of input conditions.

A frequency range of 1 cycle/10 secs to 100 Kc/s is provided.

It is particularly suited to the input of Nagard DT103 Oscilloscope, but may be used with other suitable makes.

NAGARD LIMITED

18 Avenue Road · Belmont · Surrey · Tel.: VIGilant 9161

G.E.C.

3-PORT FERRITE CIRCULATOR

The G.E.C. 3-port circulator is suitable for use as a medium power duplexer, or, with a load on port C, as a high-performance isolator.

Specification

Frequency band
Type 1 ... 9200Mc/s to 9550Mc/s
Type 2 ... 9325Mc/s to 9675Mc/s

Isolation between A & C and A & B ports over 350Mc/s frequency range ..... Greater than 30dB

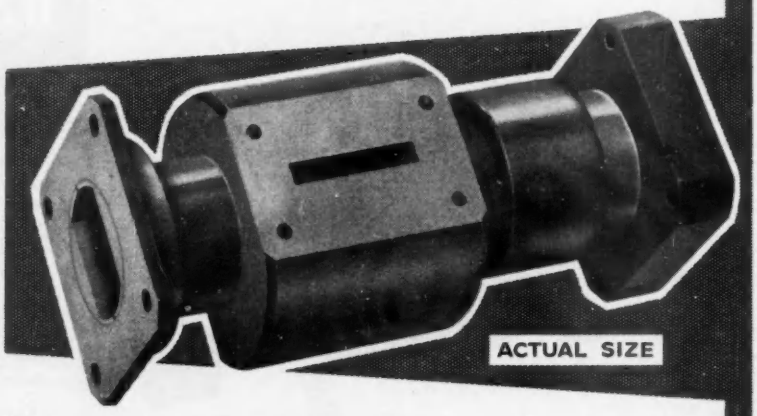
Isolation over ± 25Mc/s of design centre frequency...Greater than 50dB

Insertion Loss ..... Less than 0.2dB

V.S.W.R. over the band ..... Greater than 0.9

Power handling capacity ..... 20 watts mean

Overall length ..... 3½ inches



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THE GENERAL ELECTRIC CO. LTD. OF ENGLAND
Telephone, Radio and Television Works, Coventry, England

G.E.C. 19

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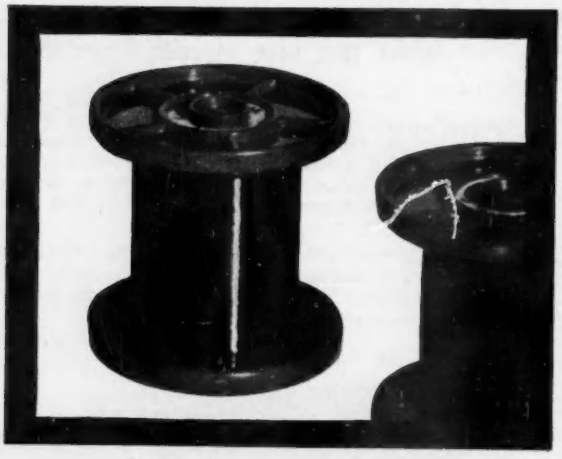
Lewcos Insulated Resistance Wires with standard coverings of cotton, silk, glass, asbestos, standard enamel and synthetic enamel are supplied over a large range of sizes



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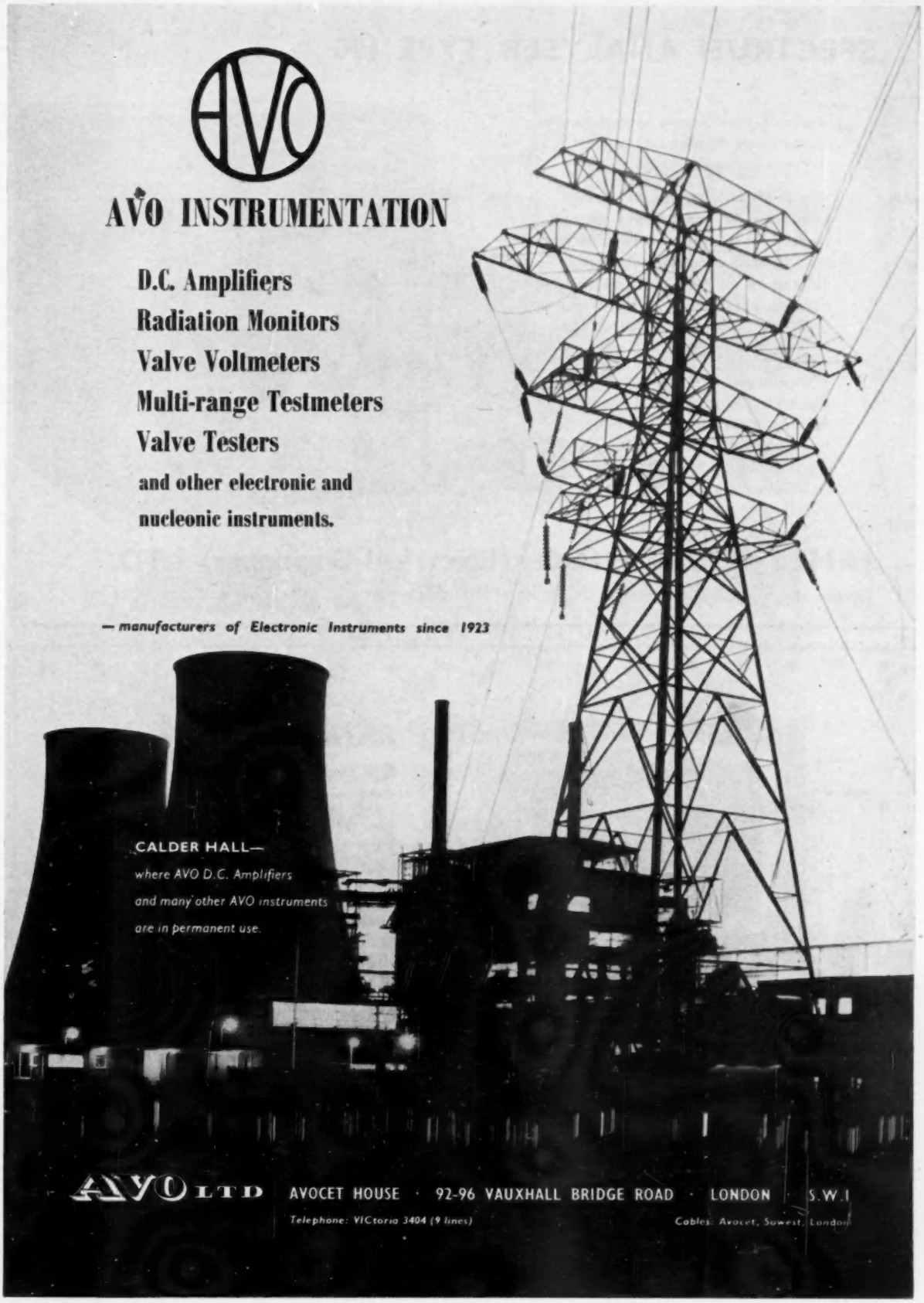

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where AVO D.C. Amplifiers and many other AVO instruments are in permanent use.

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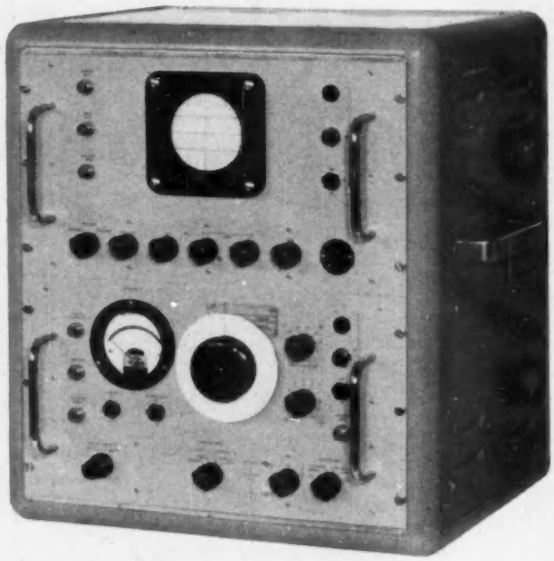
SPECTRUM ANALYSER TYPE 190 . . . . .

This sensitive and accurate instrument can be used to analyse the spectrum of a signal in the frequency range 1-90 Kc/s.

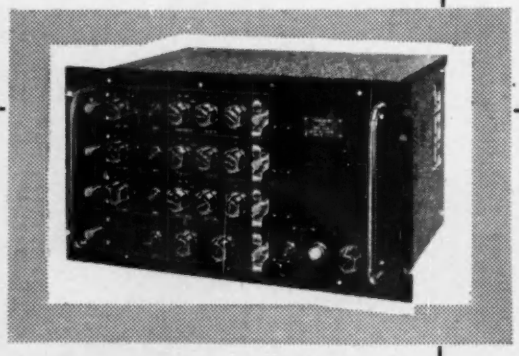
After amplification the signal is fed to a broad-band mixer supplied with a reference signal from a heterodyne oscillator sweeping either manually or automatically through the range 101 to 190 Kc/s. The lower sideband of the signal is accepted by a filter centred on 100 Kc/s and having a fixed bandwidth of either 70 c/s or 1 Kc/s.

Alternative panoramic spectrum display or accurate indication of signal power on a thermocouple milliameter is provided. Input signal components from 0.1 volt to 1 microvolt rms in a 70 c/s band can be measured with an accuracy of ±1 db.



JAMES SCOTT & CO. (Electrical Engineers) LTD.

Manufacturing and Electronics Division CARNTYNE INDUSTRIAL ESTATE, GLASGOW, E.2



coincidence unit type 1036c

The new Dynatron Coincidence Unit Type 1036C contains a 3 channel coincidence circuit which may be used in any one of the following arrangements :

I Channels 1 and 2 in coincidence.
II Channels 1 and 2 in coincidence, the output being in coincidence with channel 3.
III Channels 1 and 2 in coincidence, the output being in anti-coincidence with channel 3.
IV Channel 3 in coincidence with channels 1 or 2.
V Channel 3 in anti-coincidence with channels 1 or 2.

The three input channels and the coincidence mixer are sub-units which are removable from the front panel. The complete unit is constructed on a 10½ inch Post Office rack panel.

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NUCLEONIC & ELECTRONIC DEPT.
Dynatron Radio Ltd., Maidenhead, Berkshire

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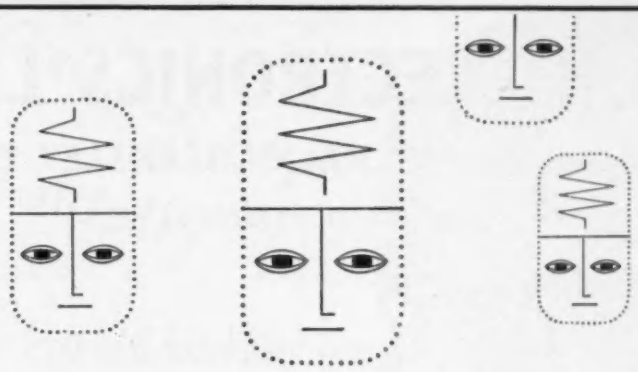

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Beckman Helipots

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HELIPOT DIVISION

Some typical examples of Helical Potentiometers :

SERIES	A	AJ	AN	B	C	T	5300	5700
Number of turns	10	10	10	15	3	1	1	1
Diameter, inches	1-13/16	7/8	1-13/16	3-5/16	1-13/16	7/8	1-1/4	3
Length of case, inches	2	1-1/2	1-63/64	2-13/16	1-9/64	25/32	19/32	1
Shaft diameter, inches (nominal)	1/4	1/8	1/4	1/4	1/4	1/8	1/4	1/4
Coil length, inches (approx.)	46	18	45	140	14	1·9	3·1	8·2
Mechanical rotation	+4° 3,600°—0°	+10° 3,600°—0°	+1° 3,600°—0°	+4° 5,400°—0°	+4° 1,080°—0°	360° cont.	360° cont.	360° cont.
Electrical rotation	+4° 3,600°—0°	+10° 3,600°—0°	+1° 3,600°—0°	+4° 5,400°—0°	+4° 1,080°—0°	354°±2°	352°±2°	358°±1°
Resistance range, ohms	25 to 450K	25 to 100K	50 to 400K	40 to 1 meg	5 to 130K	1K to 100K	25 to 49K	50 to 163K
Best pract. resist. tol. (*a*)	±1%	±2·5%	±1%	±1%	±1%	±2%	±1%	±1%
Best prac. linearity tol. (*b*)	±0·05% 1K & up	±0·05% 10K to 50K	±0·025% 5K & up	±0·01% 10K & up	±0·1% 5K & up	±0·2%	±0·25% 2K & up	±0·1% 5K & up
Max. noise millivolts (*c*)	250 2K & up	250 1K & up	100	250 5K & up	250 500 & up	100	100	100
Watts, at 25°C ambient (*d*)	6·9	2·8	6·9	13·8	4·1	1·5	2·8	6·9
Watts, at 40°C ambient	5	2	5	10	3	1·2	2	5
Weight, oz. (approx.)	4·4	1	4·5	13	2·5	0·6	2	5·9
Max. starting torque, oz. in.	2	0·7	1·3	2·7	1·8	0·05	0·7	1·3
Max. running torque, oz. in.	1·5	0·6	0·9	2	1·3	0·05	0·5	0·5
Moment of inertia, gm. cm.^{2}	18	0·3	22	200	7	0·12	2·8	8·6
Max. taps	28	32	28	80(*e*)	14	9	9	33
Min. distance between taps	20°±1°	45°±2°	20°±1/2°	15°±1°	20°±1°	30°±1°	30°±1°	10°±1°
Max. ganged sections	3	consult factory	2	3	3	5	no ganging	8
Life expectancy, shaft revs.	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000

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Winston Electronics also manufacture Voltmeters,
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Can you say Toroidally Wound Rheostats twelve times quickly?

It's a bit of a mouthful but you need only say it once preceded by the name 'Cressall'. Whether you require the vitreous enamelled Cressall "Torostat" (illustrated below) of extremely robust ceramic unit construction or the well known open-wound type of rheostat or potentiometer, you will find none better than Cressall.

Forty years' experience in design and manufacture ensure that each Cressall product has extra quality inbuilt.

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Mechanical Relay Latch
FOR
P.O. TYPE 3000

This latching device enables the P.O. 3000 type relay to be held in the closed position when the coil is de-energised and until manually released.

Does not impair the versatility of the contact arrangements, nor affect the normal mounting position.

Fitted with "local" release latch.

WILL TRIP AND HOLD ON A.C. CURRENT

Please send for illustrated leaflet.

Illustration shows 3000 Type Relay fitted with "Remote" release latch.

EITHER TYPE CAN BE FITTED TO YOUR EXISTING 3000 TYPE RELAYS IN A MATTER OF MINUTES.

Jack Davis (Relays) Ltd
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TELEPHONES: MUSEUM 7960 LANGHAM 4821

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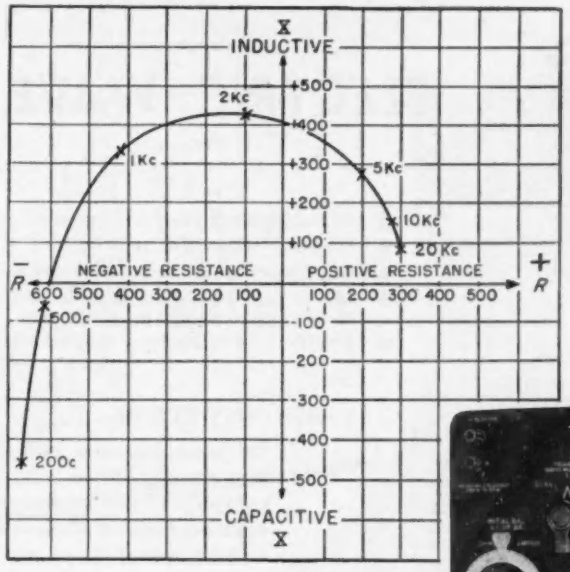
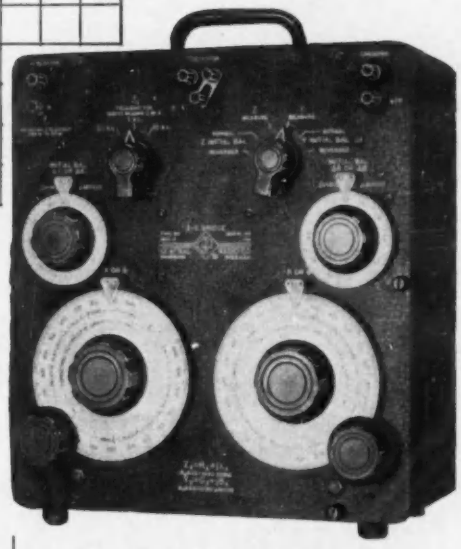


Impedance of Feedback Circuit . . . illustrates ability of the Z-Y Bridge to measure any impedance; quadrature components may be positive or negative, real or imaginary.

GENERAL RADIO COMPANY TRADE MARK

Type 1603-A Z-Y Bridge



Measures Any Impedance...

- From O to ∞ ohms
- Positive or Negative
- At Any Phase Angle
- Over 20-cps to 20-kc Range

The General Radio Z-Y Bridge measures impedances from short circuit to open circuit, at small or large phase angle. Quadrature components, R & X or G & B, are measured directly at calibrated 100 c, 1-kc, and 10-kc bridge positions. Basic accuracy is 1% over most of this range.

The ability to measure impedances of any magnitude accurately with one instrument is an extremely valuable asset in many measurement situations. The Z-Y Bridge can be used for measuring conductivity of liquids, in dielectric cells as readily as it can be used for R-L-C component measurements in the laboratory or production-test department. It will measure open-circuit and short-circuit transformer parameters . . . impedances of batteries and electrolytic capacitors . . . characteristics of audio-transmission networks . . . impedance of electro-acoustic transducers . . . Q and resonant frequency of chokes . . . and impedances of feedback loops, since negative real parameters can be directly measured.

The Bridge also can be used to determine cable-fault locations and circular-arc plots of liquids or solids having lossy polarizations in the audio-frequency range. These are but a few of the countless applications for this unique and versatile device. *You name it — this Z-Y bridge can probably measure it.*

For complete information request a copy of the current "G.R." Catalogue "O" (258 pages), where data is given on pages 34/35.

Impedance and Admittance Range
R: ±1000 ohms G: ±1000 μmhos
X: ±1000 ohms B: ±1000 μmhos

Accuracy
R or G: $\pm(1\% + (2 \text{ ohm or } 2\ \mu\text{mho}))$
X or B: $\pm(1\% + (\frac{2f_c}{f} \text{ ohm or } \frac{2f}{f_c}\ \mu\text{mho}))$

f is operating frequency, f_c is frequency setting of panel selector switch

Impedances of less than 100Ω or (100 μmhos) can be measured on "Initial Balance" dials with considerably greater accuracy—
R or G: $\pm(1\% + (0.2 \text{ ohm or } 0.2\ \mu\text{mho}))$
X or B: $\pm(1\% + (\frac{0.2f_c}{f} \text{ ohm or } \frac{0.2f}{f_c}\ \mu\text{mho}))$

Frequency Range—20 cycles to 20 kc

Maximum Applied Voltage
130 volts, rms on bridge;
less than 32v on unknown

Accessories Recommended
"G.R." Type 1210-B Unit R-C Oscillator and
"G.R." Type 1212-A Unit Null Detector

Accessories Supplied
2 Shielded Cables for generator and detector

Dimensions—12½" x 13½" x 8½"

Net Weight—21½ lbs.

Type 1603-A Z-Y Bridge £222

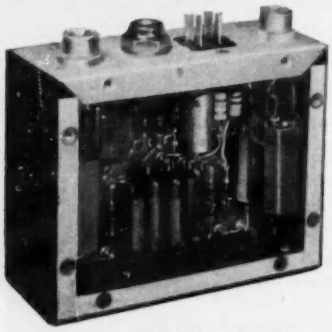
Claude Lyons Ltd.

76 Oldhall Street Liverpool 3, Lancs.
Telephone: Central 4641/2

Valley Works, Ware Road, Hoddesdon, Herts.
Telephone: HODdesdon 3007-8-9

CL.45

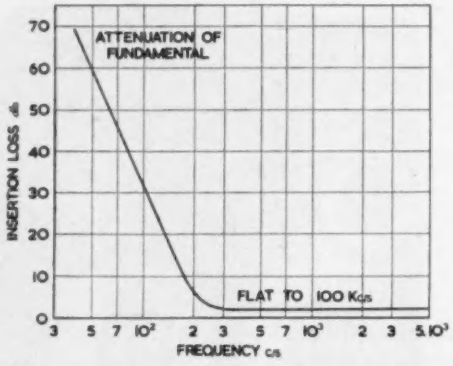
EE 3121 *for further details*



SIZE 4½"×3½"×1¾"

ELECTRIC WAVE FILTERS

★ *LC and RC filters based on modern theory, techniques and components*
★ *Frequency range: D.C. to 10 Mc/s.*
★ *Advanced design methods lead to high performance and compact units*
★ *Low or high pass, band pass, or band stop filters can be designed to individual performance specification*
★ *Amplifiers can be combined with the unit if required*



HIGH PASS FILTERS

The curve illustrates the performance of a filter for suppressing 50 c/s hum. The filter is on "active RC" type, and provides a light-weight, compact unit. A small flat loss, and great flexibility of source and load resistances are other desirable features of such units.

PAMPHLET No. 1232a ON REQUEST

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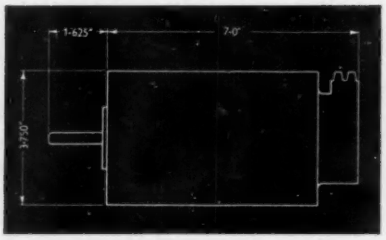
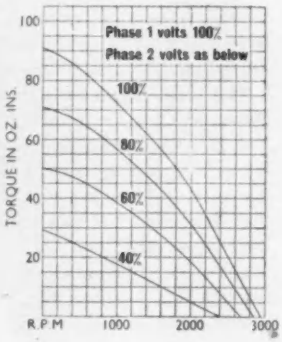
London Office: 15 Victoria Street, S.W.1

Introducing a NEW 50~A.C. SERVO motor





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High-speed motors:	Tachometer generators:
Synchronous motors:	Speed governors and accurate governor-controlled machines:
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Moment of Inertia of the Rotor 220 x 10^{-6} slug ft²

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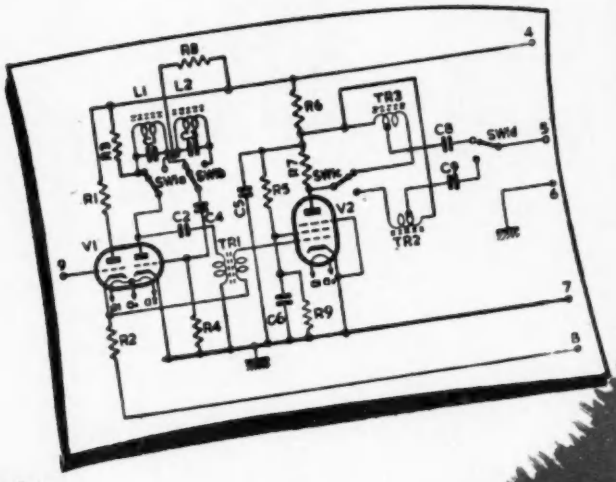

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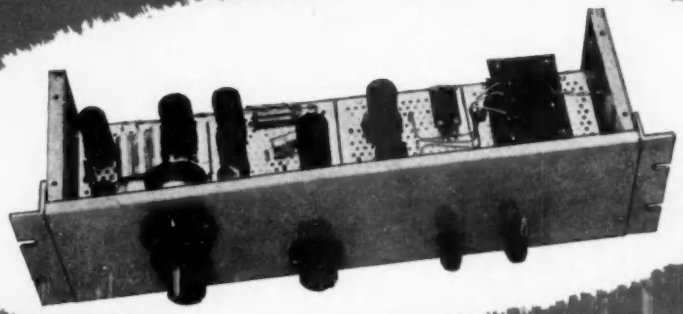
- ★ A wide range of accessories permit the construction of bench or rack mounted units for permanent use.
- ★ Units can be fitted together almost indefinitely in a variety of ways.

IT ALL ADDS UP TO THE SAVING OF YOUR TIME AND MONEY



Full details sent upon request

ALL-POWER TRANSFORMERS LTD.

CHERTSEY ROAD, BYFLEET, SURREY TELEPHONE: BYFLEET 4411

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Remote control by Varley Solenoids saves time and money. 100% British in design and manufacture. All normal voltages and ratings "off-the-shelf". For any specific application, prototypes—7-10 days, quantity production—3-4 weeks.

Varley REGD. TRADE MARK **SOLENOIDS**

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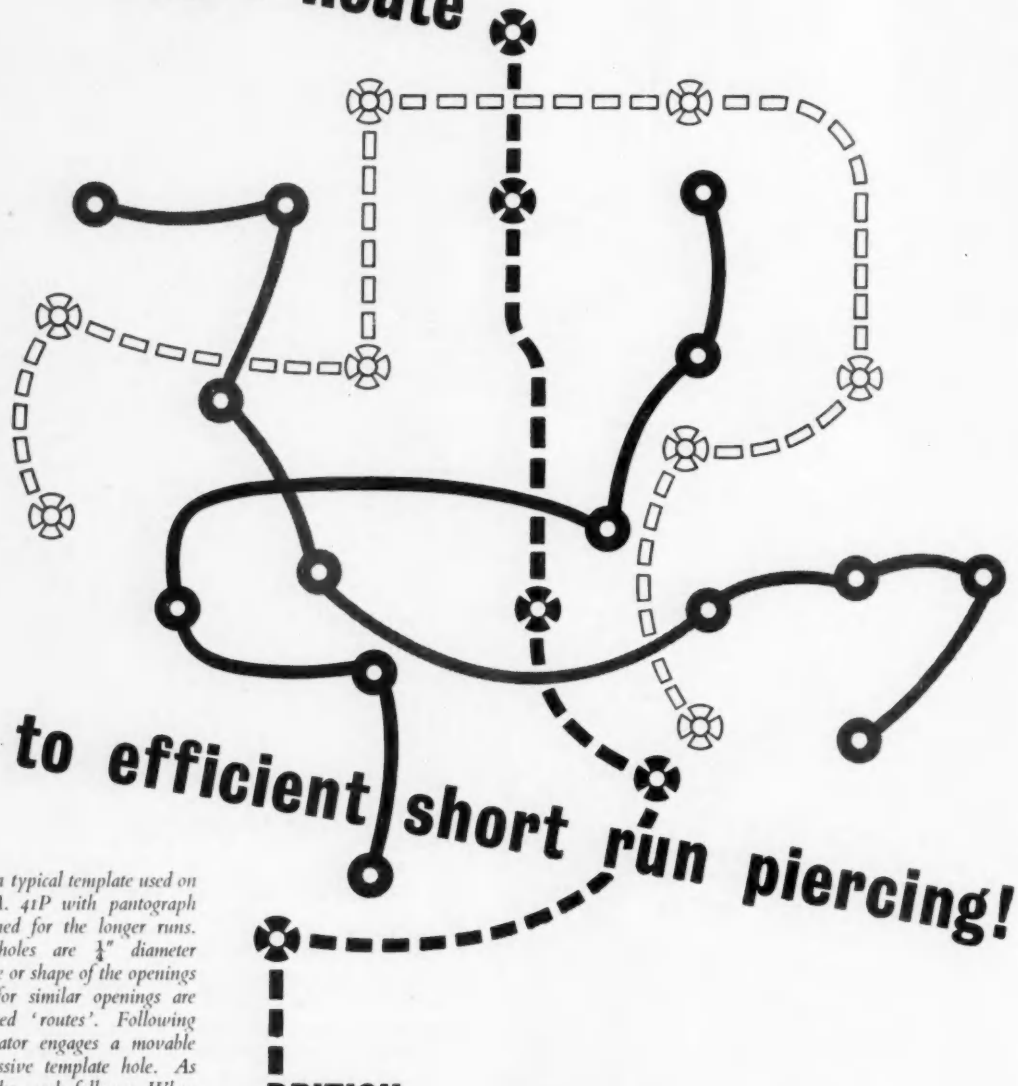

to efficient short run piercing!

This is a section of a typical template used on the Wiedemann RA. 41P with pantograph table specially designed for the longer runs. All the template holes are ¼" diameter irrespective of the size or shape of the openings in the job. Holes for similar openings are connected by coloured 'routes'. Following each route the operator engages a movable stylus in each successive template hole. As the stylus is moved the work follows. When the last hole is reached the operator indexes the turret to the next position and starts on the next 'route' ensuring the least number of work and turret movements.

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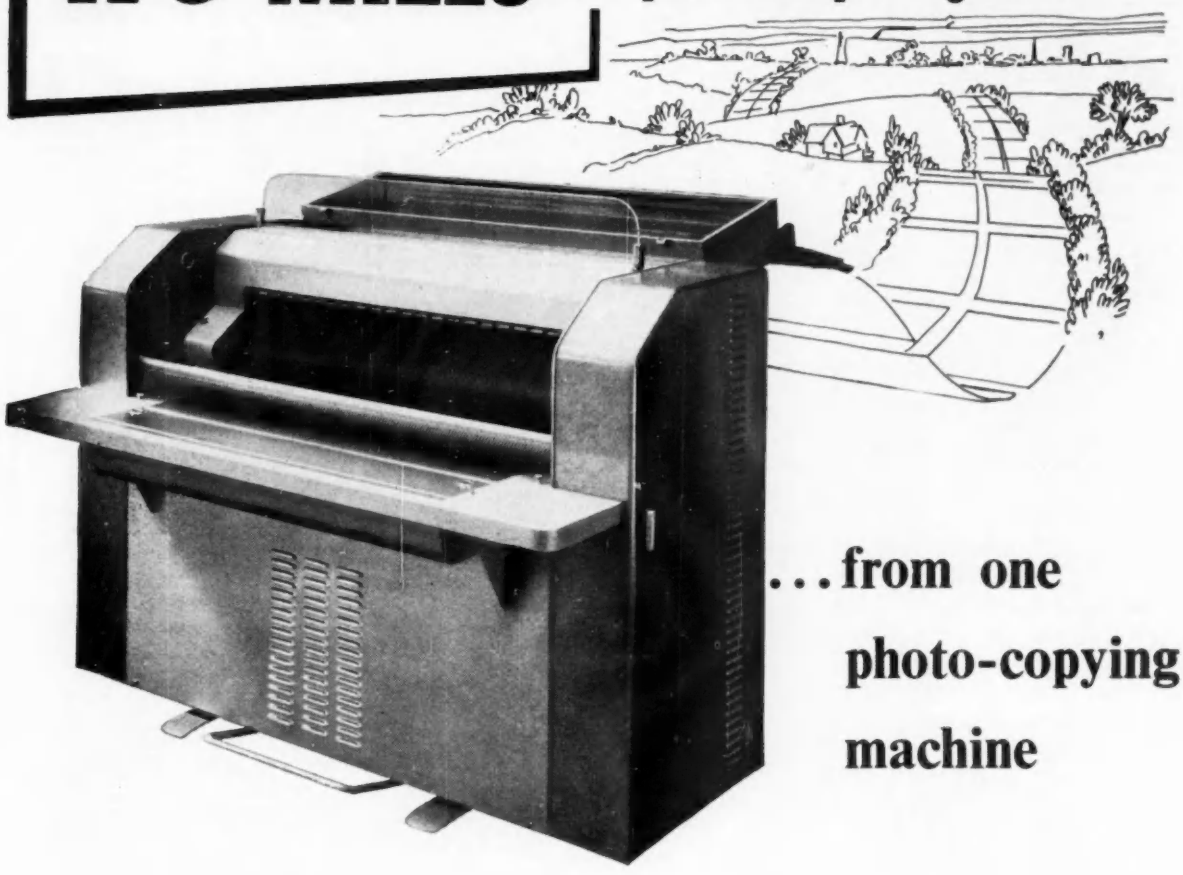

. . . from one photo-copying machine

175 miles of prints a year is the output reported by one regular user of an Azoflex Model 246 — and that's the sort of output that any busy drawing office can expect. The AZOFLEX photo-printing process combines several unique features. It's the *only* daylight reflex copying process. It's the *only* process to apply a measured quantity of developer irrespective of running speed, thus ensuring optimum quality. It avoids the use of dangerous chemicals and there are no unpleasant fumes. Operation is quiet and free from vibration. Exposing, developing and print delivery are all synchronised to ensure an even flow of finished work at all speeds.

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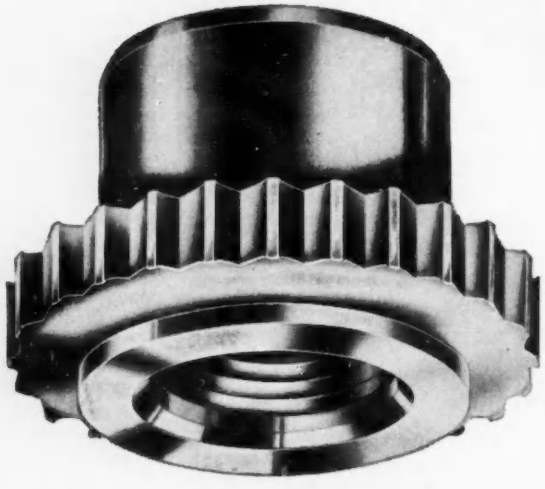
OPAS

ACTUAL SIZE OF A 4 BA NUT



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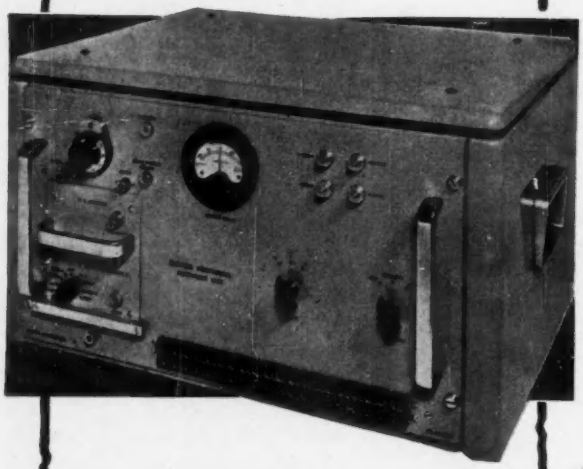

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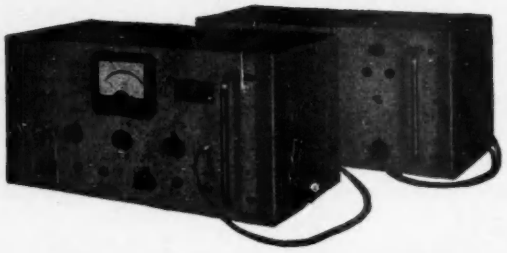

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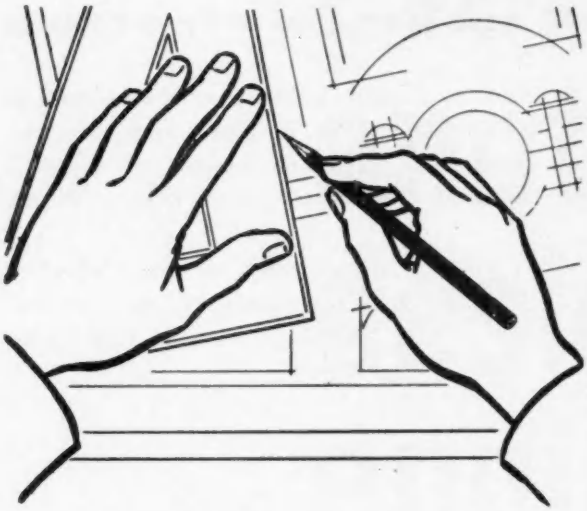

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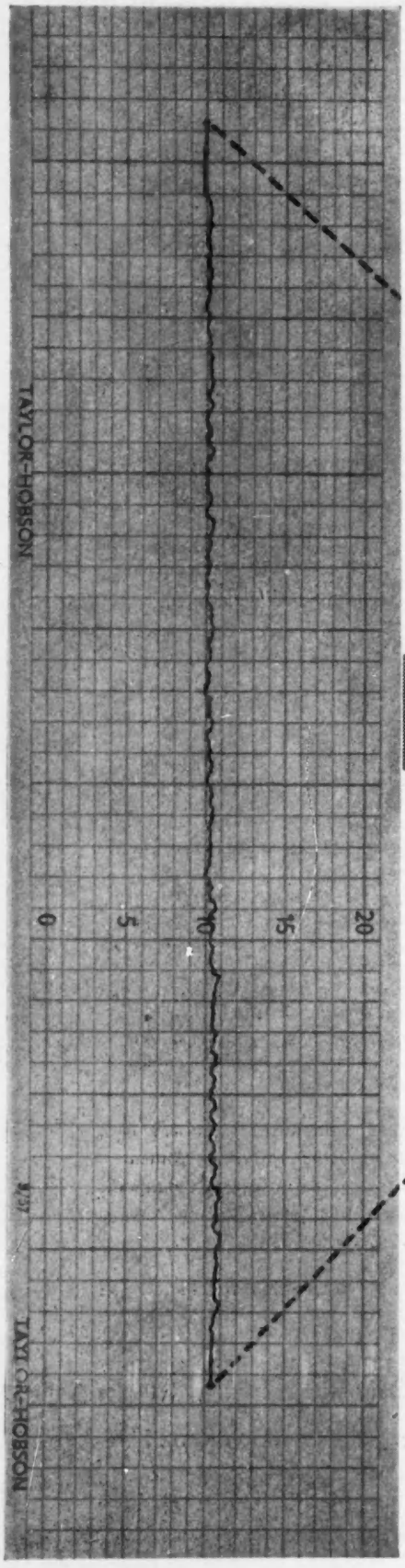

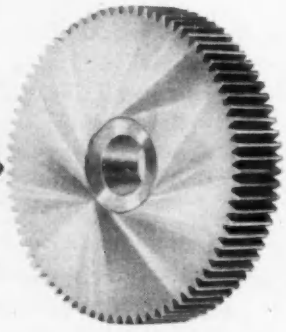

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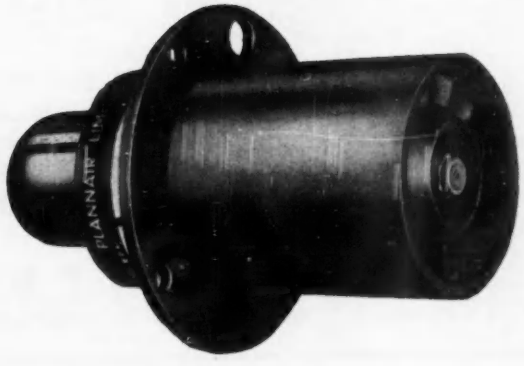

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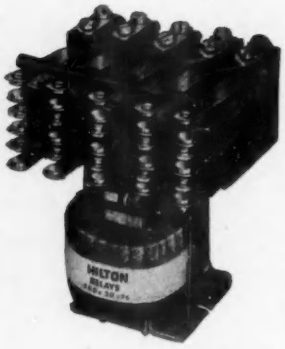

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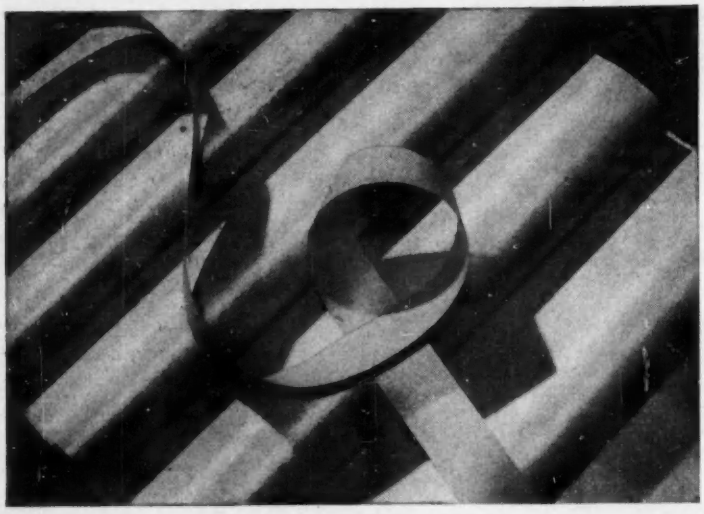

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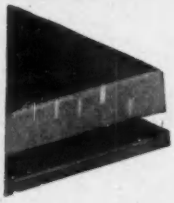

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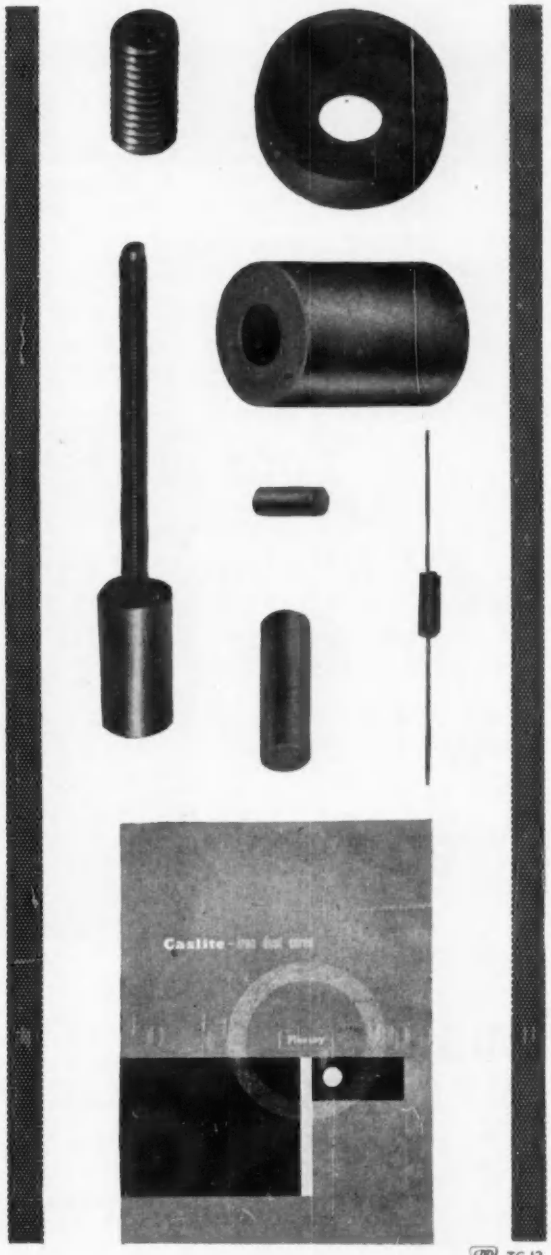

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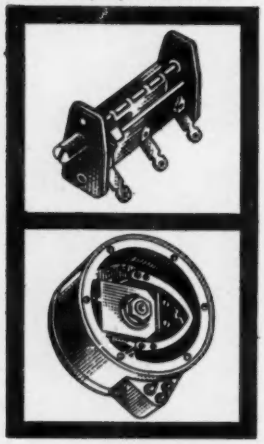

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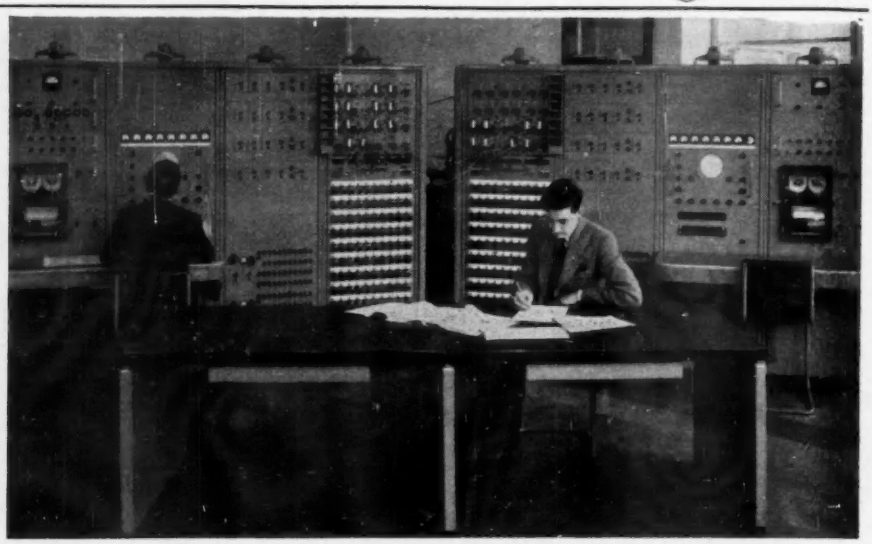

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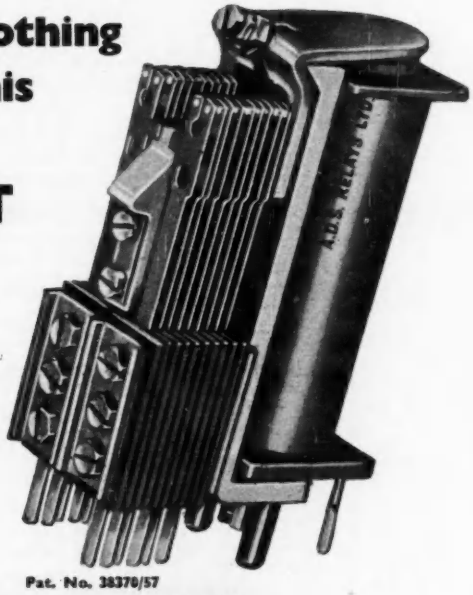

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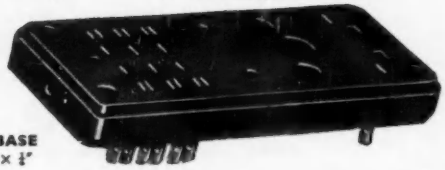

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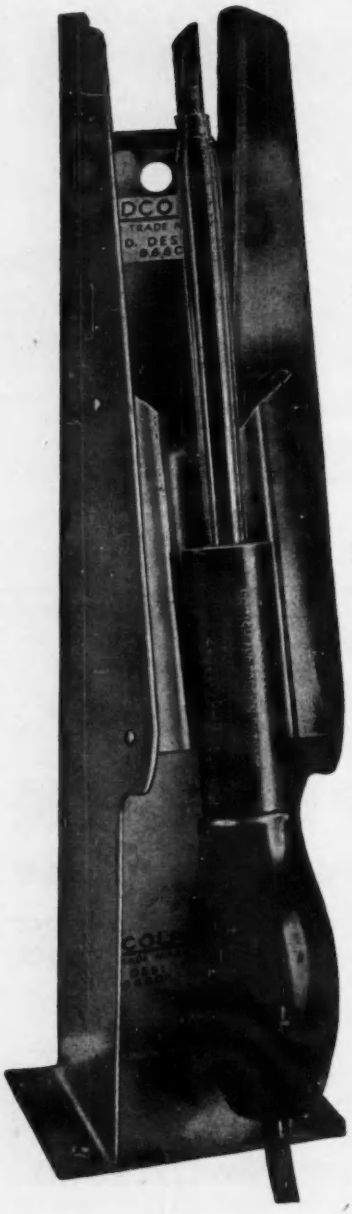

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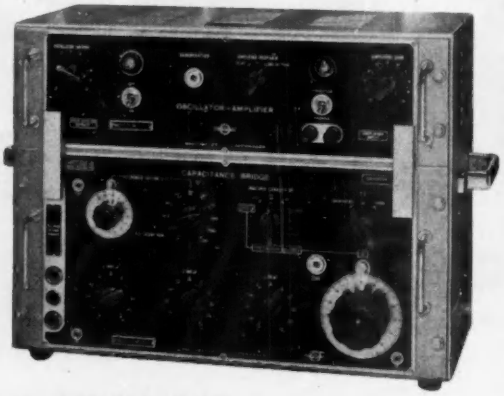

Type **CMB1/OSF2**

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ACCURACY:
0.1% above 5 $\mu\mu$F
0.0005 $\mu\mu$F below 0.1 $\mu\mu$F

FREQUENCY RANGE:
200 cps to 5 kc/s
with full accuracy

POWER FACTOR RANGE:
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(at 1000 cps)

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Y AMPLIFIERS. Input Impedance: 2·2 megohms shunted by 15 pF approx. Input R.C. coupling time constant: 0·22 seconds. Input Attenuator: 10:1 frequency compensated. Amplification: 26 to 800 continuously variable. Signal Calibration: ±2 volts in 0·1 volt divisions. Calibration Accuracy: ±5%. Frequency Response: D.C. to 100 Kcps 10% down. D.C. to 150 Kcps 30% down. Output Swing: 400 volts at a mean level of 150 volts above earth. Linearity of output: ±2%.

X AMPLIFIERS. Input Impedance: 1 megohm shunted by 50 pF approx. Amplification: 11 to 210 continuously variable. Frequency Response: D.C. to 150 Kcps 10% down. D.C. to 300 Kcps 30% down. Output Swing: 440 volts at a mean level of 150 volts above earth. Linearity of output: ±2%.

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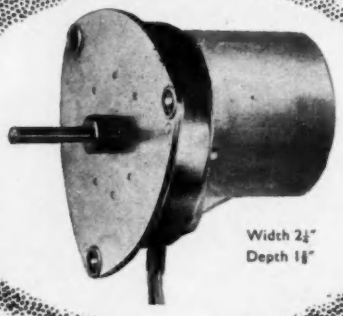

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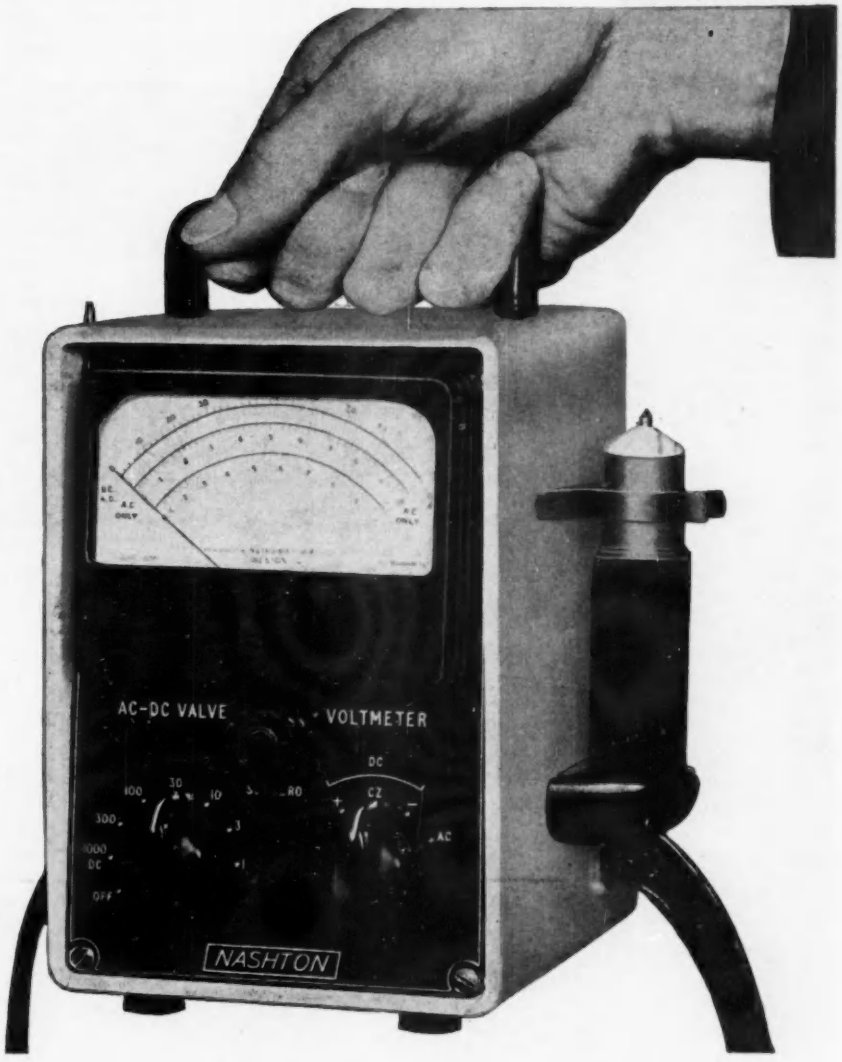

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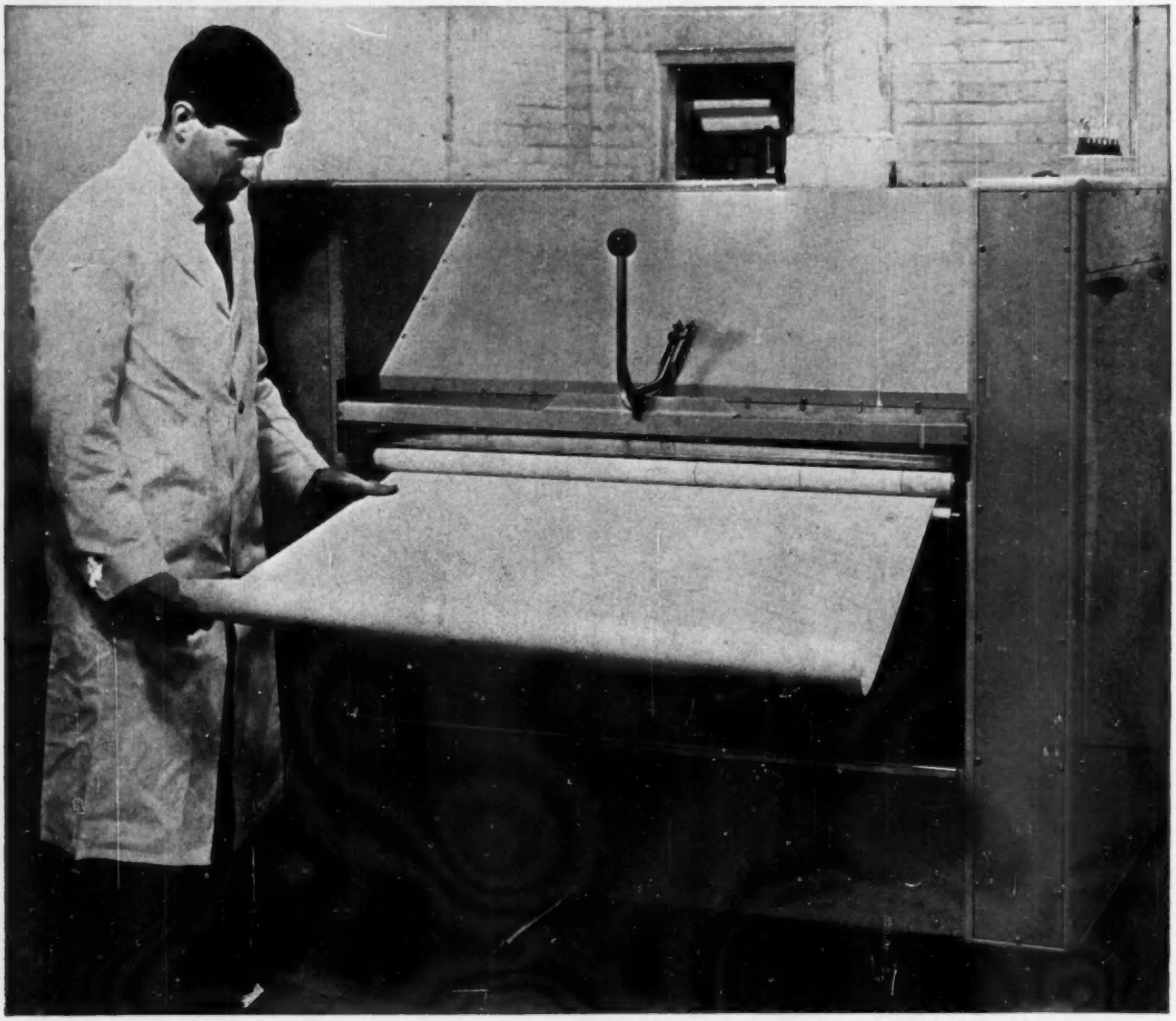

Dunlop Rubber Co. Ltd., Cambridge St., Manchester 1, supplied the 'Fluon' covering for the rollers in this 24-channel oscillograph recorder made by Southern Instruments Ltd., Camberley.

'Fluon' rollers used on 24-channel oscillograph recorders

ROLLERS ON THIS E.2400 24-channel cathode ray oscillograph recorder and auto processor unit are made from 'Fluon' p.t.f.e. Into this machine photographic paper in 200-ft. rolls, 40 in. wide is fed. A record emerges developed, fixed and dried at about 1¼ in. per second.

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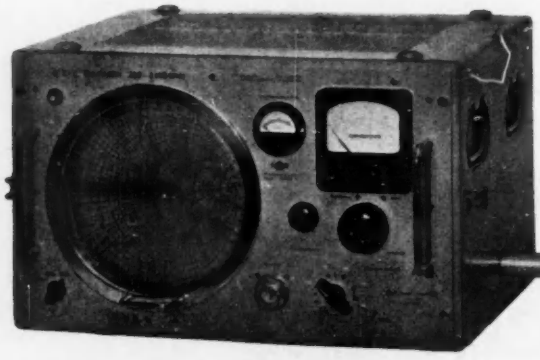

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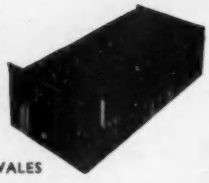

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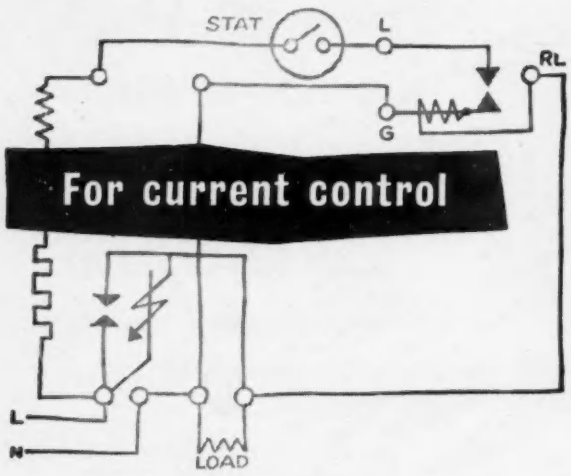

...SPECIFY SUNVIC

Sunvic components are widely used for controlling equipment such as moulding presses, furnaces, incubators, chemical plant, etc. Together with the Sunvic potentiometric recorder they also have numerous applications in scientific and industrial research particularly for measuring, controlling and recording temperature and small electrical quantities.

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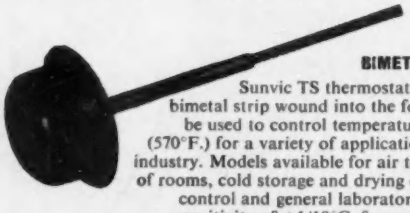

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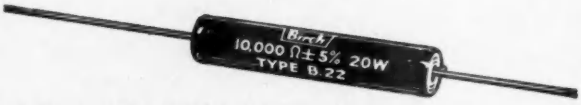

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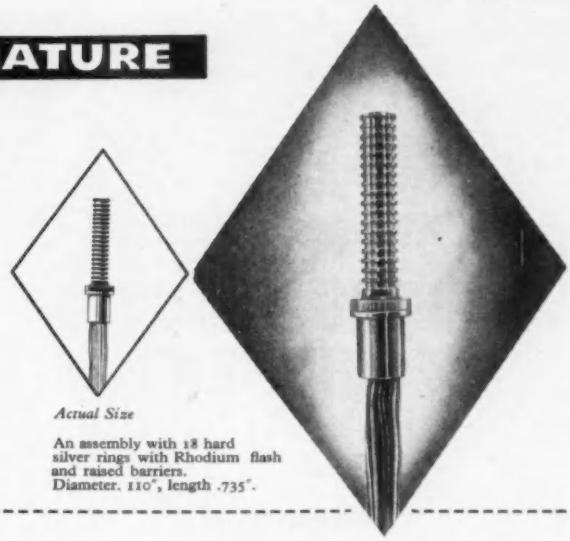
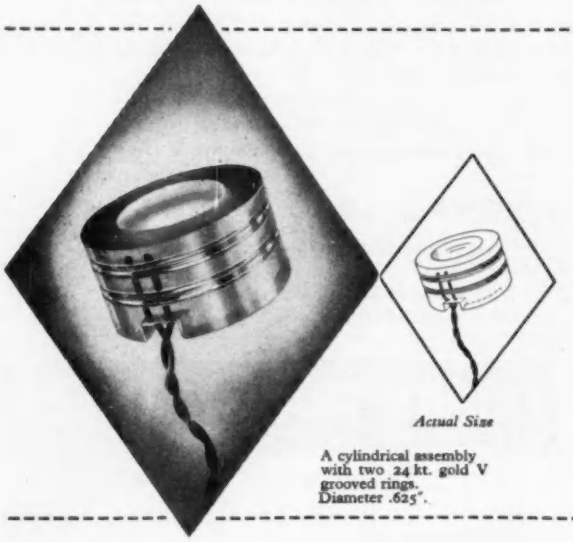


Actual Size

An assembly with 18 hard silver rings with Rhodium flash and raised barriers. Diameter. 110", length .735".



Actual Size

A cylindrical assembly with two 24 kt. gold V grooved rings. Diameter .625".

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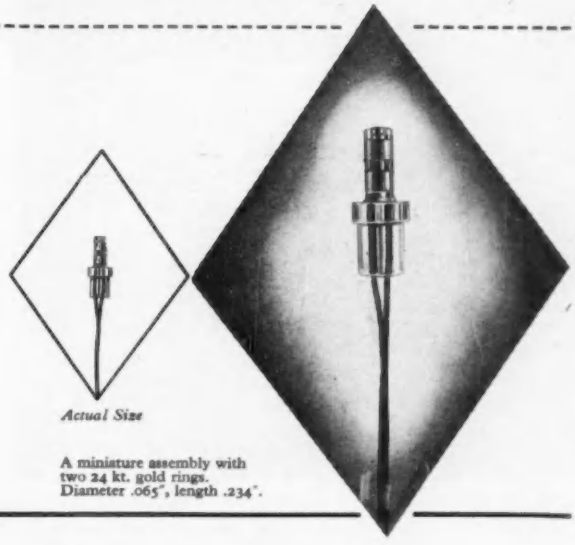

Actual Size

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Further information may be obtained from:—

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Whitley Kiln, Basingstoke Road, Reading, Berks.

Telephone : Reading 82557/8

* *Patent No. 748480. I.D.M. Electronics Ltd., Sole Licencees in the United Kingdom.*

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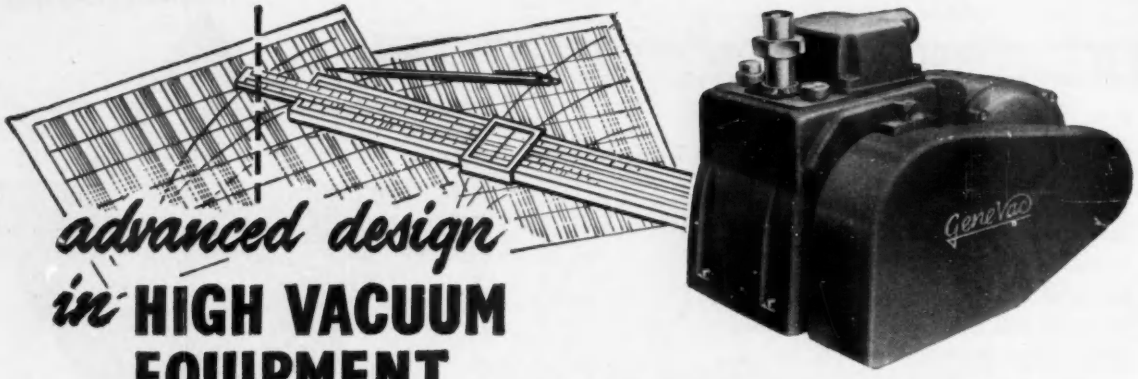

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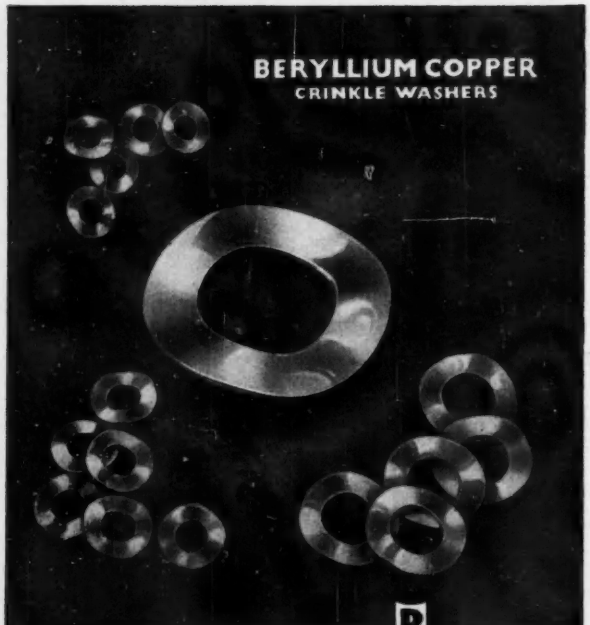

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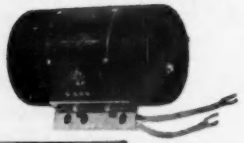

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For dual cable runs in seventeen sizes, covering cable diameters $^{1}/_{32}$ in. up to $^{21}/_{32}$ in. In highest grade hard P.V.C.

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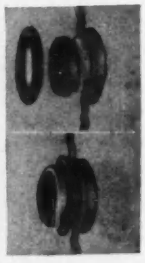

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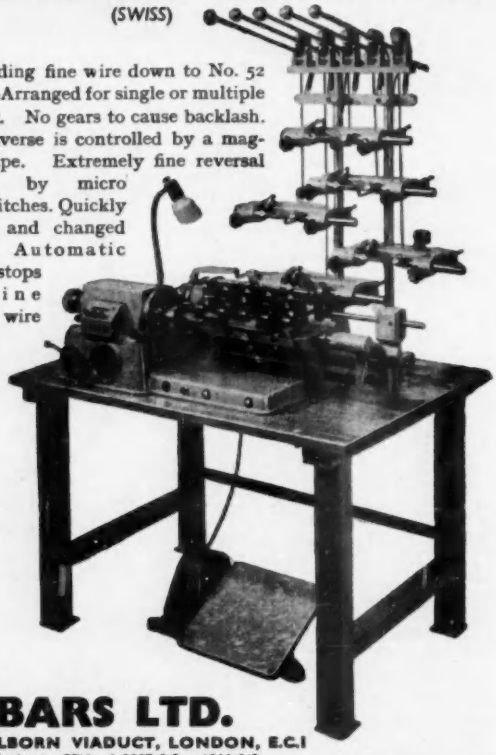

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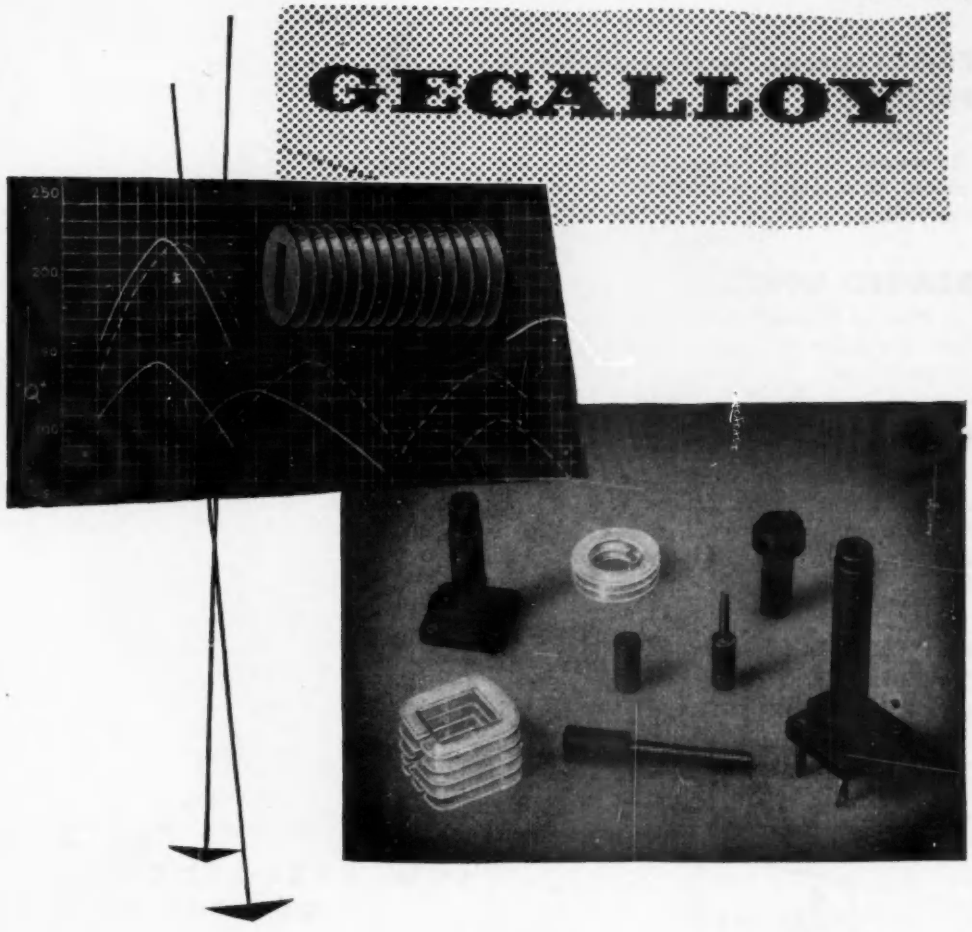

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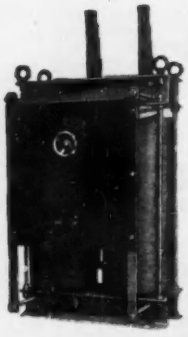
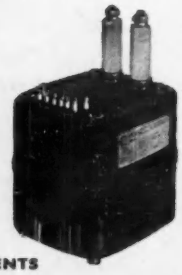


The illustration is of a 60 KVA Transformer with 5,000 amp. Secondary, with tapped Primary to give secondary voltage variation from 12 volts to 4 volts. Primary tap changes are made with a rotary switch as shown. These Units are designed and tested to BSS 171 where applicable, or appropriate B.S. Specification.



This is a typical example of our "C" Core range. We manufacture both open and hermatically sealed types, wound to customers specifications. This range extends from 10 VA to 1.6 KVA at frequencies up to 2,000 cps.

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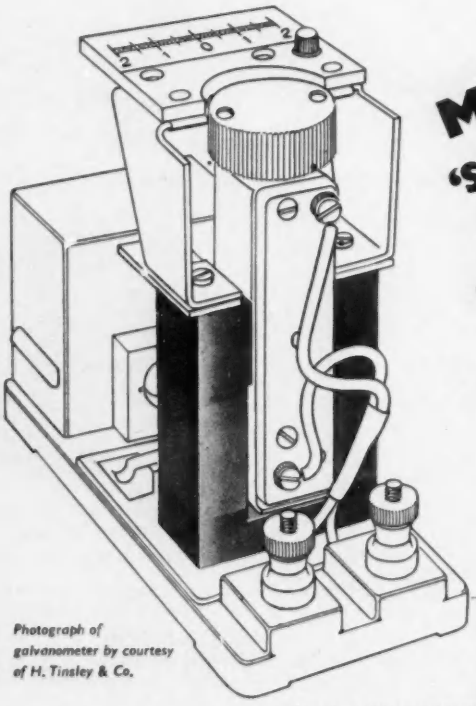
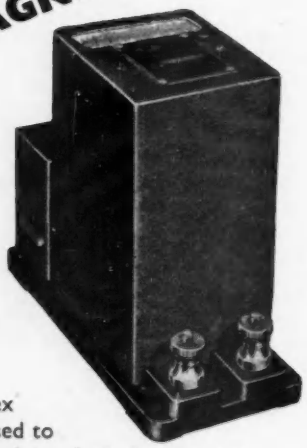


Photograph of galvanometer by courtesy of H. Tinsley & Co.

MUREX 'SINCOMAX' MAGNETS are used in this new TINSLEY MINIMUS GALVANOMETER



In this galvanometer Murex 'Sincomax' Magnets are used to meet the need for low leakage, high flux density and magnetic stability.
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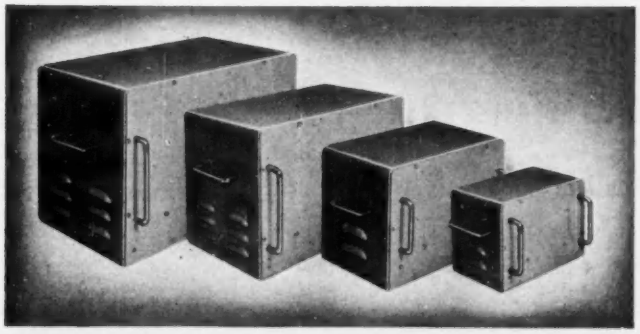

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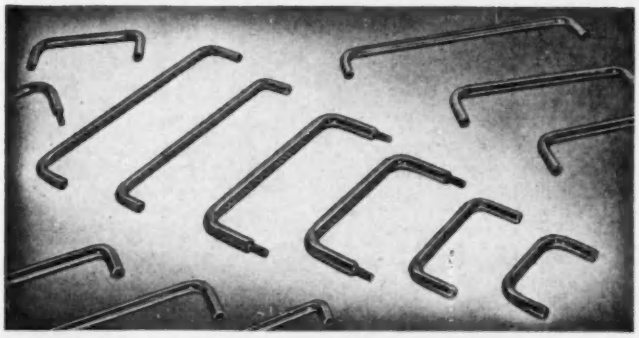

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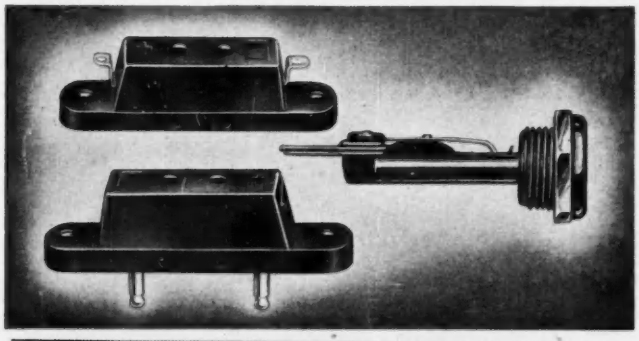

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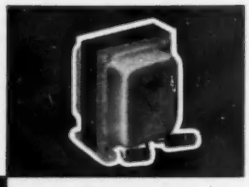

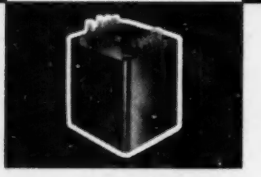

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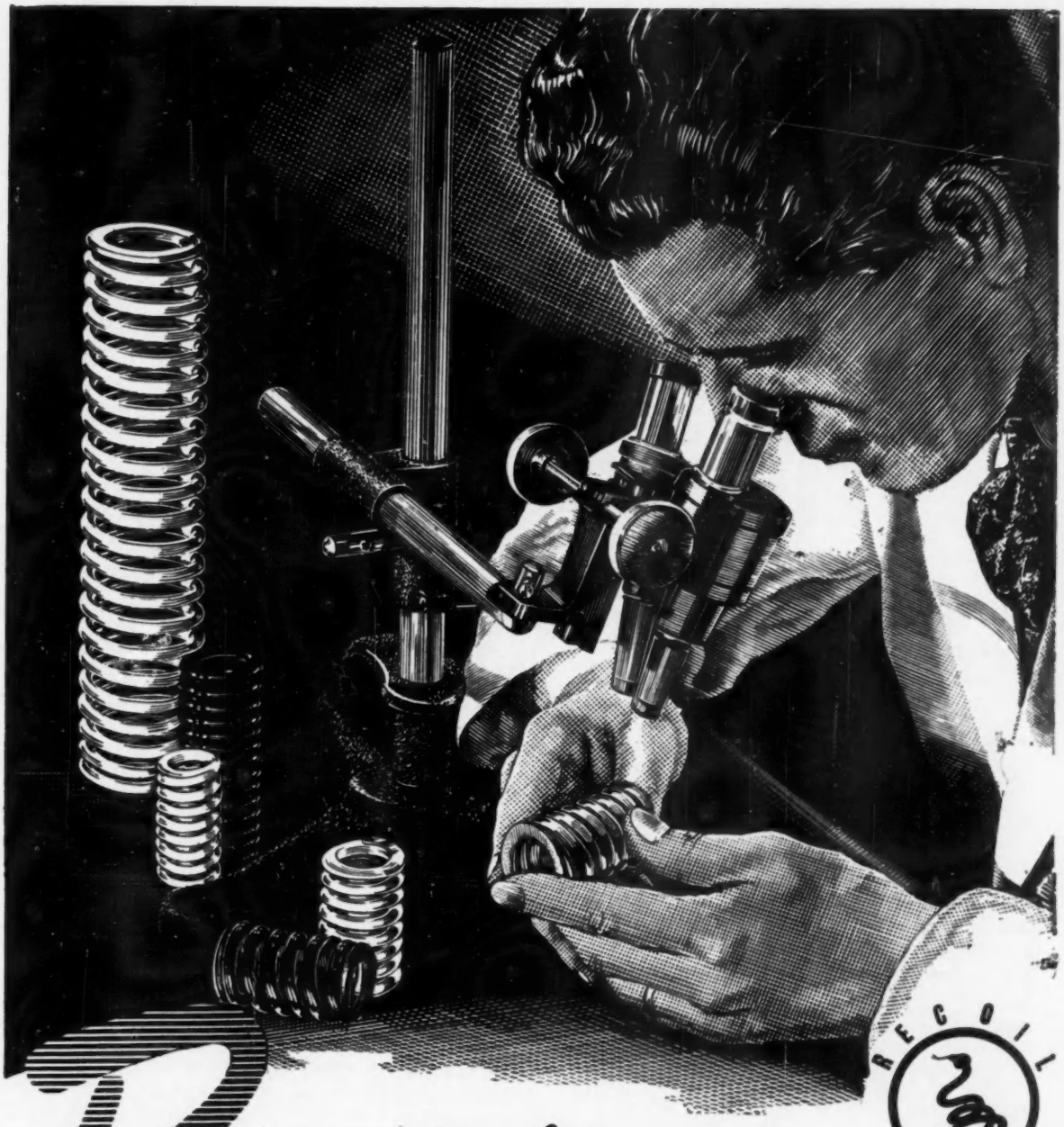

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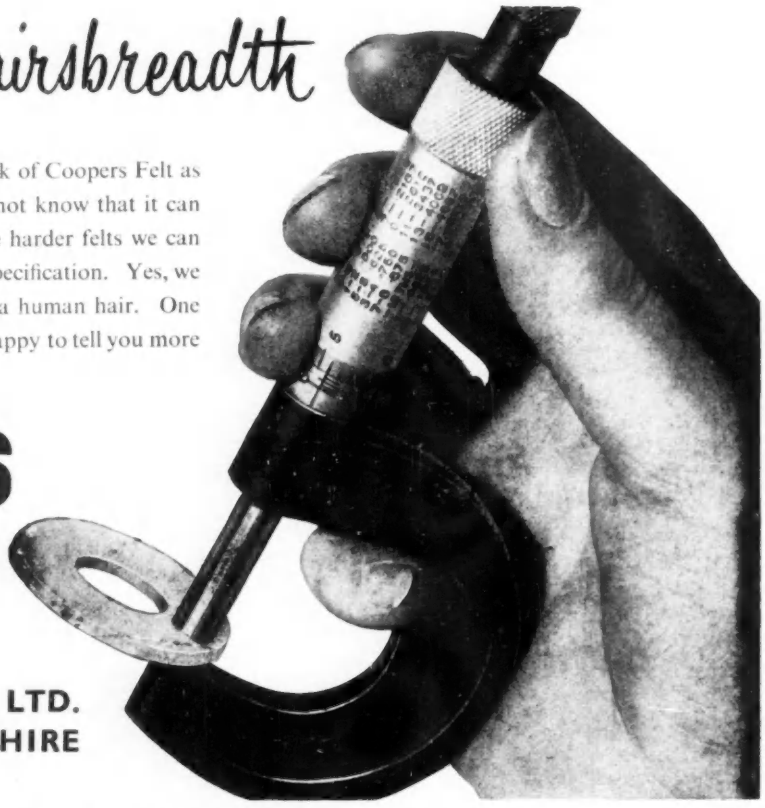

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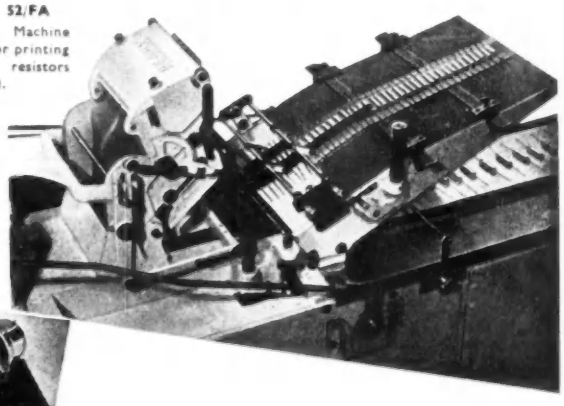

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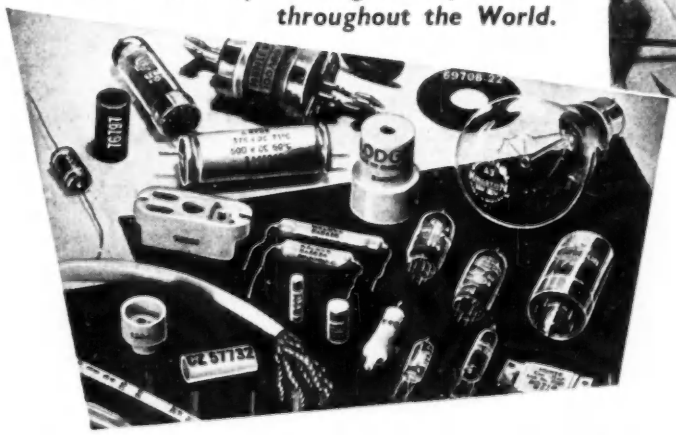

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0 - 1 Megohms
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All voltage measurements, a.c. and d.c. are at 10,000 ohms per volt.

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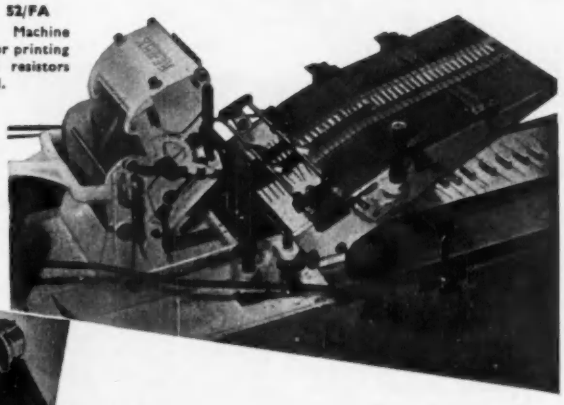

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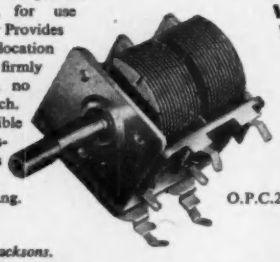

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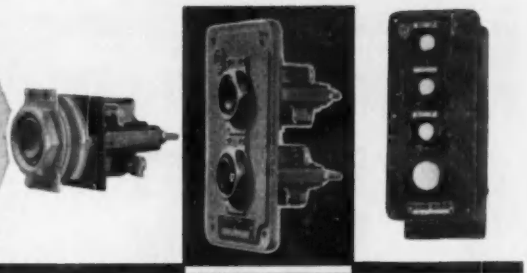

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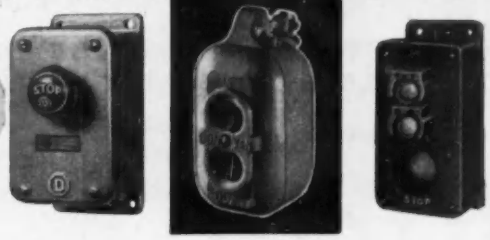

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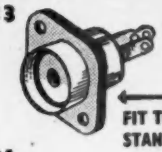

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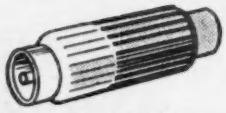

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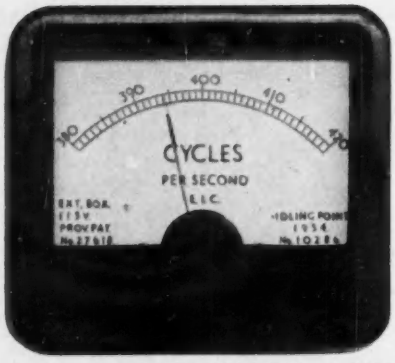

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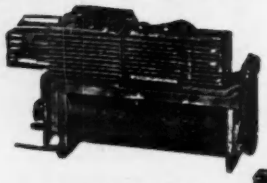

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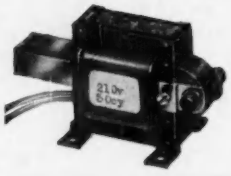

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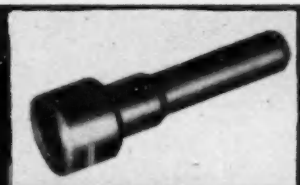

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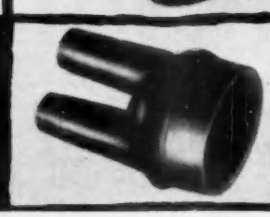

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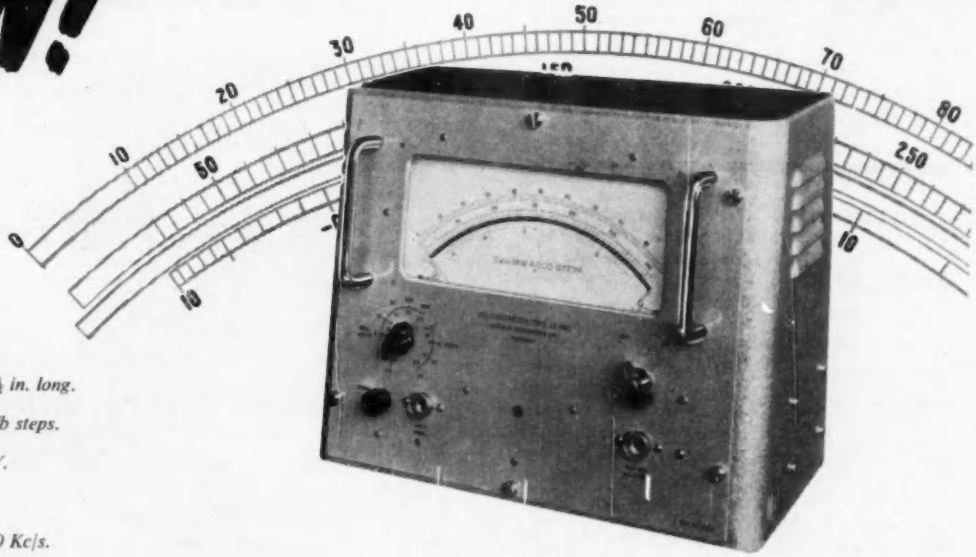

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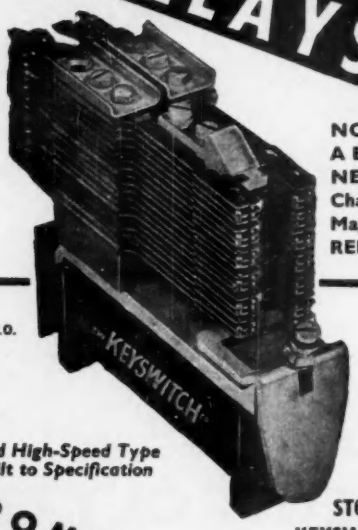

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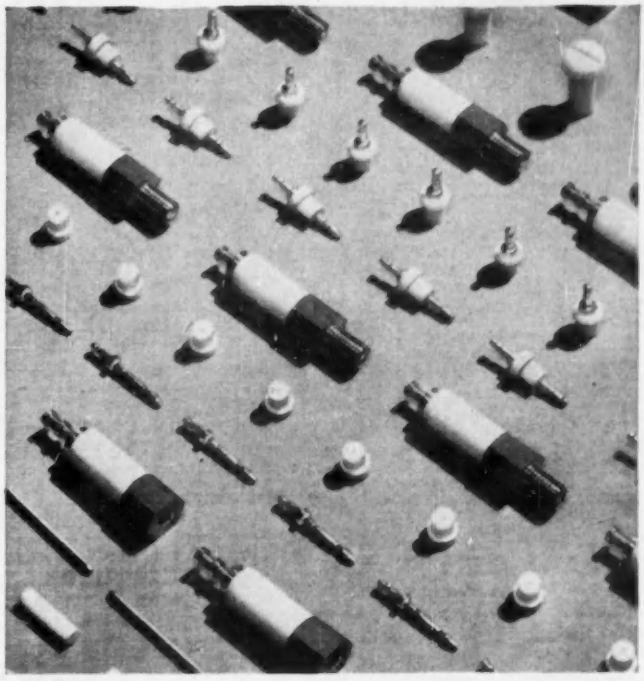

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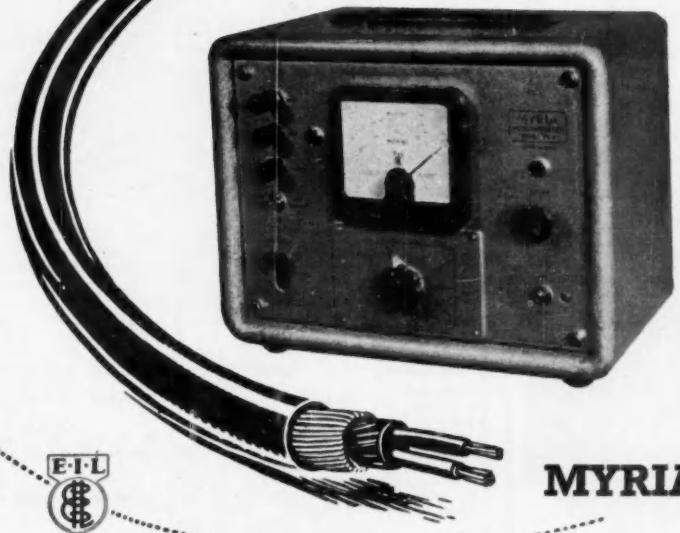

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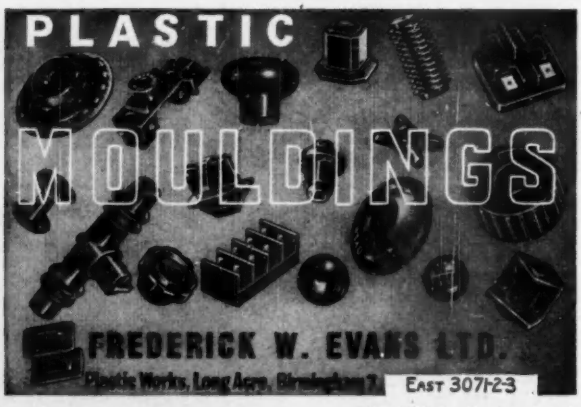

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Coincidence Transmitter	AP10429		AP10636	AP10682	AP10739	AP11112
X-CO Transmitter		AP10747			AP10952	
F.T. Transmitter	AP10667		AP10689	AP10741	AP10742	AP10742M
Hunter incdg.	AP3946	AP6548B	AP10854			
S.A. Hunter	AP6548	AP10731	AP10965	AP10645	AP10732	AP10872
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SY-L Hunter	OS1901A		OS1902A			
Resolver	AP10640 AP10650	AP10859 AP10860 OS3423A	AP10961 AP10966		AP10874	
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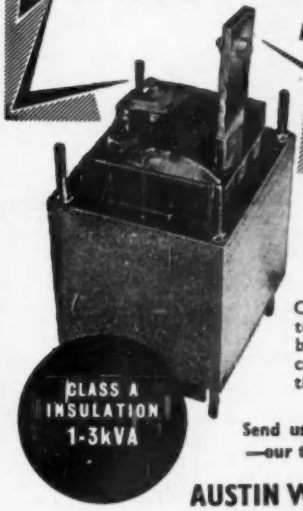

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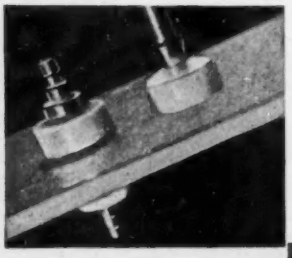
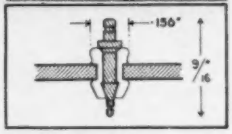
(Type 156)



A new compact lead-through, speedy to assemble, and of outstanding physical characteristics. *Patent applied for.* The polytetrafluorethylene bush, which is supplied with the heavily silver-plated brass barb partly inserted, is positioned in a hole .156" in dia. Firmly pressing the barb through the assembly expands the P.T.F.E. bush on the far side of the chassis and locks it firmly in position.



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CAPACITY Less than .75mmF.
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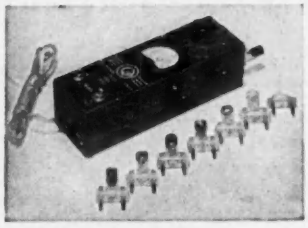

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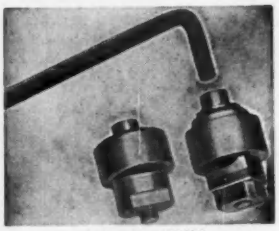

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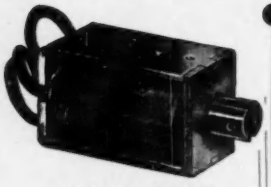

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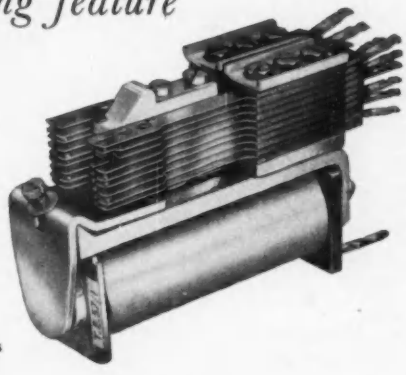

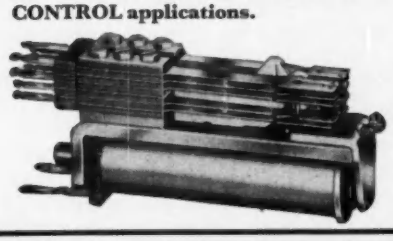

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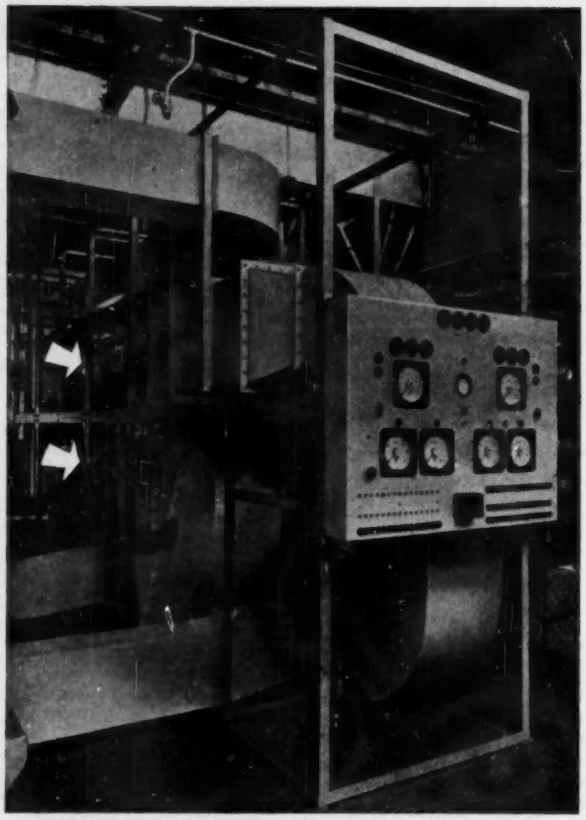

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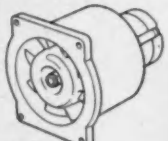
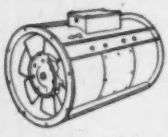


2.4" 400 c.p.s. fan.



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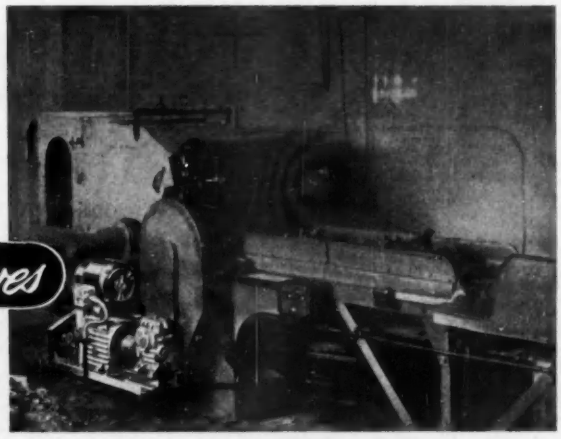

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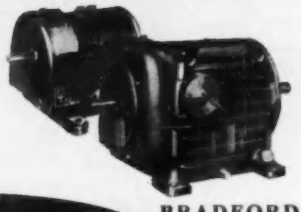

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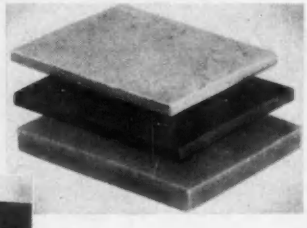

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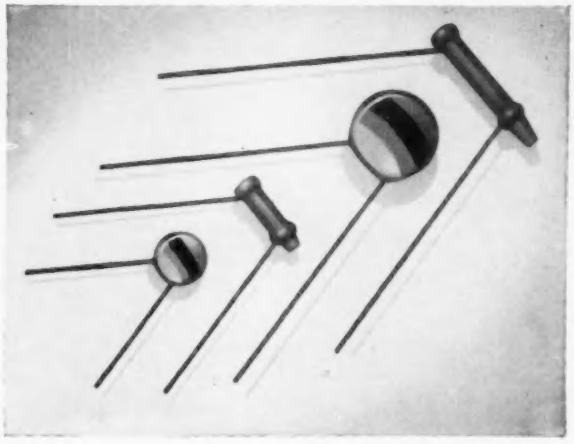
Tubular and Disc Ceramics



Hunts announce their new ranges of Tubular and Disc Ceramics. Precise in their characteristics and robust in design, these capacitors are available in High-K, High-Q and Special Purpose Tubulars and in High-K Discs. Full technical specifications on request.

HIGH-Q TUBULAR
STANDARD CAPACITANCE RANGES

Capacitance Range Picofarads	Length of Insulated Tube Millimetres
*Type P100. Temperature Coefficient $(+100 \pm 100) \times 10^{-6}$ pF/pF/°C	
1.5 to 7	11
7.1 to 11	13
11.1 to 16	16
16.1 to 26	21
26.1 to 33	26
33.1 to 40	31
40.1 to 50	36
50.1 to 60	41
*Type N33. Temperature Coefficient $(-33 \pm 60) \times 10^{-6}$ pF/pF/°C	
5.0 to 27	11
27.1 to 45	13
45.1 to 69	16
69.1 to 100	21
100.1 to 140	26
140.1 to 180	31
180.1 to 220	36
220.1 to 250	41
*Type N750. Temperature Coefficient $(-750 \pm 250) \times 10^{-6}$ pF/pF/°C	
10.0 to 80	11
80.1 to 110	13
110.1 to 180	16
180.1 to 240	21
240.1 to 350	26
350.1 to 450	31
450.1 to 550	36
550.1 to 650	41

*Capacitors with closer limits of Temperature Coefficient can be supplied by special arrangement.

HIGH-K TUBULAR
STANDARD CAPACITANCE RANGE

Capacitance Picofarads	Length of Insulated Tube Millimetres	
	TB1000	TB3000
470	11	—
680	11	—
800	11	11
1000	13	11
1500	16	11
2000	19	11
2200	19	11
3000	—	16
3300	—	16
4000	—	19
4700	—	19
5000	—	21

POWER CERAMICS

Ranges of Power Ceramics and Temperature Compensating types are also available.
Details on application.

HIGH-K DISC
STANDARD CAPACITANCE RANGE

Capacitance Picofarads	Type Number	Diameter (over insulation) Millimetres
470	CD8K/2	9
680	CD8K/2	9
1000	CD9K/2	10.5
1500	CD9K/2	10.5
2200	CD11K/2	12
3300	CD12K/2	13
4700	CD14K/2	14.5

MATERIAL EMPLOYED

The temperature coefficient graph of the material is such that the capacitance increases with temperature from 20°C until it reaches a peak at approximately 50°C. With a further increase of temperature the capacitance falls, reaching its 20°C value again at approximately 80°C.
Maintenance of capacitance is thus ensured from 20°C to 80°C.

HUNTS

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- Safety latch protecting record button.
- Off, record and playback push buttons.
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- Peak level recording meter.
- Record amplifier gain control.
- Playback amplifier gain control 3 watts undistorted output.
- Output from playback pre-amplifier to feed external amplifier.
- Radio or pick-up input socket.
- Meter zero control.
- Microphone input socket.
- Output socket to external speaker when used mutes internal speakers.
- 2 matched loudspeakers.
- Tape drive lever, giving instant start and stop.
- Bib tape splicer.
- Variable speed between 8 and 3¾ i.p.s.
- Neon lit stroboscope showing precise speeds of 7½ and 3¾ i.p.s.
- Easy tape loading into straight slot.
- 3 separate heads, erase, record and playback.
- Clock-type tape position indicator.
- 8½" reel capacity.
- 3 silent running Garrard motors.
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- Case, with lid, finished in luxan hide and pigskin colours.
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These features and many others are incorporated in the Reflectograph Model 500. The retail price of 94 guineas is only made possible by the controlled quantity production of these instruments, of which the original development costs were absorbed in the supply of models to Recording Studios, Laboratories and Broadcasting Stations.

During the next few months supplies of the Reflectograph Model 500—the professional recorder restyled for use in the home—will be available only from selected High Fidelity and Tape Recording Specialist retailers. For further details please write to the address below.

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